DEPARTMENT OF PUBLIC WORKS
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COUNTY OF SAN BERNARDINO
ECONOMIC DEVELOPMENT
AND PUBLIC SERVICES GROUP

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KEN A. MILLER
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February 17, 2004

Mr. Gerard J. Thibeault, Executive Officer
California Regional Water Quality Control Board
Santa Ana Region
3737 Main Street, Suite 500
Riverside, California 92501-3339

RE: SUBMITTAL OF WORK PLANS FOR ADDITIONAL INVESTIGATIVE AND MODELING WORK, CLEANUP AND ABATEMENT ORDER R8-2003-0013, VOC AND PERCHLORATE IMPACTED GROUNDWATER, FORMER BUNKER AREA, RIALTO, CALIFORNIA

Dear Mr. Thibeault:

In response to your directive of January 15, 2004, the County of San Bernardino Solid Waste Management Division (County) has prepared the attached Work Plans for additional field investigation and groundwater modeling to better characterize impacted groundwater downgradient of the former Bunker Area property in Rialto, California. The first Work Plan identifies work that the County will perform to install and sample additional groundwater monitoring wells and to evaluate aquifer properties within the project area. The second Work Plan details supplemental groundwater modeling that will be completed to evaluate contaminant transport conditions.

In addition to the attached Work Plans, the County is also submitting an initial response to the technical comments included in your letter of January 15, 2004. Though comments made by third parties were attached to your directive, we are responding only to your letter. While it is unfortunate that the County was not provided an opportunity to review and discuss these issues, we believe the attached memorandum addresses the most salient issues included in your letter. For example, and perhaps central to the RWQCB's critique of the County's earlier investigative work, the RWQCB has asserted that the County's groundwater model did not support an interpretation of a limited release from the former Bunker Area. Specifically, the RWQCB noted that, in deviating from the values that were incorporated in the U.S. Geological Survey's (USGS's) model of the Rialto-Colton Basin, the County's model underestimated groundwater velocity and likely contaminant transport. As described in the attached memorandum, we believe that this statement misrepresents the two models. In fact, rather than underestimating the groundwater velocity in the project area, the County's model appears to provide for equivalent or greater transport velocity than the USGS model.

The County of San Bernardino looks forward to working with the RWQCB during completion of the upcoming field investigation and modeling efforts. We expect that with improved communication between the County and the RWQCB there will be less of an opportunity for misunderstandings to arise and that work to mitigate groundwater impacts in the project area may begin shortly.

If you have any questions or concerns, please contact me at (909) 386-8703 your earliest convenience.

Sincerely,

Peter Hart Wulfman

Peter H. Wulfman, P.E.
Division Manager

PHW: ALR: js

cc: Ken A. Miller, Director of Public Works
Robert Jocks, Deputy County Counsel
Joel S. Moskowitz, MBW&B

GeoLogic Associates
Geologists, Hydrogeologists and Engineers

MEMORANDUM

TO: Peter Wulfman, SWMD
Art Rivera, SWMD

FROM: Gary Lass, GLA
Ralph Murphy, GLA

DATE: January 27, 2004
Revised February 17, 2004

RE: RWQCB COMMENTS
PERCHLORATE INVESTIGATION REPORT

In its comments regarding the Bunker Area perchlorate investigation, the RWQCB focused largely on the groundwater modeling work that was completed by GLA to substantiate an assertion that GLA's results are insufficient to support conclusions regarding the likely transport distances for Bunker Area impacts. By using different hydraulic conductivity values than were used in a USGS model of the Rialto-Colton Basin, the RWQCB contends that GLA has under-estimated the distance that the perchlorate plume has traveled and that the plume has likely traveled to and beyond well N-10. As described herein, the RWQCB's letter and the comments from consultants representing Task Force members misrepresent both the values used in GLA's model and the effect that these values have on the model results.

While GLA's model is similar to the USGS model, it should be recognized that it includes data that was unavailable to the USGS and that its focus is on a much smaller area within the uppermost groundwater zones identified by the USGS. While the USGS model is an important tool for evaluating general groundwater conditions in the Rialto-Colton Basin, it may not be appropriate to assess contaminant transport conditions within the relatively restricted project area. Key differences between the two models include:

- The USGS model "lumps together" the 3 uppermost aquifers in GLA's model (i.e. the Upper, Intermediate, and Regional Aquifers) into a single aquifer (the USGS's Middle Water-Bearing unit). As such, it ignores the local hydrostratigraphy in the project area including the aquitard that separates the first two water zones from the Regional Aquifer. In fact, GLA's findings indicate that an important determinant for contaminant transport in the area is the geometry of the aquitard between the impacted Intermediate Aquifer and the unimpacted Regional Aquifer. (It should be noted that the vertical hydraulic gradient between the Intermediate Aquifer and the deeper Regional Aquifer is typically greater than 50 feet and that the total thickness of the Intermediate Aquifer is only about 100 to 125 feet.)
- GLA's model was calibrated to wells that were installed solely within the Intermediate Aquifer. The USGS's model was calibrated to wells that were constructed largely within GLA's Regional Aquifer or to "hybrid" wells that were screened within both the Intermediate and Regional Aquifers and, as a result, the two models are not comparable.

For example, since the horizontal hydraulic gradient in the Regional Aquifer is flatter than that in the Intermediate Aquifer, the USGS's model calibration efforts typically required higher hydraulic conductivity values than GLA's model which was calibrated to the steeper gradient of the Intermediate Aquifer. Note that the "Layer 3" model results in the USGS model indicate that the project area hydraulic gradient is about 0.011 ft/ft, while groundwater-monitoring wells that were constructed in the Intermediate Aquifer near the site indicated a gradient of about 0.019 ft/ft. GLA's model indicates a gradient of 0.017 ft/ft more closely matching observed conditions.

- Rather than under-estimating hydraulic conductivity, the northern 70% of GLA's model integrates a hydraulic conductivity of 40 feet per day. As shown on Figure 20 (page 51) of the USGS model report, the USGS assumed a very similar hydraulic conductivity of 35 feet per day in this area. Since the estimated 4000-foot plume transport distance in GLA's model occurs within the zone modeled as having a hydraulic conductivity of 40 feet per day, it appears to match quite well with the USGS data set.

- GLA's use of a hydraulic conductivity of 9 feet per day occurred only in the southern-most 30% of our model where the USGS employed a value of 80 feet per day. While GLA's use of 9 feet per day is significantly lower than that used by the USGS, the use of a value less than 80 feet per day is supported by aquifer pumping test data (Well N-7 test data indicates that the hydraulic conductivity is locally about 20 feet per day). Model calibration efforts ultimately yielded the 9 feet per day used by GLA in this area.

  Since the single pulse Bunker Area plume did not extend to the area when the 9-foot per day hydraulic conductivity was used, the only way that the use of lower hydraulic conductivity value could have affected calculated transport distance is by creating a flatter hydraulic gradient near the Bunker Area[1]. As described above, however, GLA's model results indicate a hydraulic gradient that is steeper than the USGS model, and one that is in good agreement with the gradient measured by monitoring wells in the area.

- Finally and perhaps most importantly, GLA's model was developed using hydraulic conductivity values that were determined in two aquifer pumping tests near the landfill rather than through "back-calculations" of well efficiency test results. GLA's tests yielded results of 60 feet per day in a well (F-5) that includes an especially thick and coarse interval, and 20 feet per day in a well (N-7) where finer grained aquifer materials were more influential in the test. Recognizing that fine-grained materials represent approximately 40% of the alluvial section in the Intermediate Aquifer, use of a value of 40 feet per day was considered appropriate and yielded good calibration results.

  Since no aquifer test data was available in the southern portion of the model area, GLA's use of a hydraulic conductivity value of 9 feet per day relied more heavily on calibration results.

(1) – Remember that velocity (and thus transport distance) is a function of hydraulic conductivity (K) and hydraulic gradient (I) divided by porosity (n): $(V = KI / n)$.

Considering the differences that necessarily exist between the GLA and USGS models, the following statements included the RWQCB's letter (identified in italics) appear unsubstantiated:

RWQCB Statement:

> *"it appears that GLA's three-dimensional groundwater model and selected hydrogeologic parameters, specifically hydraulic conductivity values for the water-bearing sediments in the immediate and downgradient areas of the MVSL, are not representative of the local aquifers. For layer 3 (Intermediate Aquifer), GLA assigned a hydraulic conductivity of 40 feet per day in the northern portion of the model and 9 feet per day in the southern portion of the model. In contrast, the USGS (page 49) used hydraulic conductivity values that range between 35 to 80 feet per day. The hydraulic conductivity values used by GLA were significantly lower than those used by the USGS, and would result in contaminants migrating a much shorter distance with respect to time than what actually may be occurring".*

Response:

As detailed above, GLA's model focuses on the uppermost groundwater zone (unrecognized by the USGS), was developed taking into account local hydrostratigraphic conditions, and employs hydraulic conductivity values that are in general agreement with aquifer pumping test data. In addition, GLA's hydraulic conductivity values in the immediate area of interest (i.e., immediately southwest of the Bunker Area) are nearly identical to, and, in fact, slightly higher than the USGS value (40 ft/per day vs. 35 ft/per day).

RWQCB Statement:

> *"Also, the perchlorate that is present at the location of the downgradient most monitoring well, N-10, in concentrations that are about twice that found at the location of monitoring well N-9, which is located approximately 1900 feet upgradient of N-10, is likely a result of a pulsed release of perchlorate from the bunker area and not an indication of the County's plume ending in the vicinity of monitoring well N-9 and the "regional" plume being present in monitoring well N-10, as the evaluation report contends".*

Response:

No information is provided by the RWQCB or in comments from the Task Force consultants to support an assertion of a pulsed release. This possibility was considered in GLA's report but was considered unlikely owing to the general historical absence of VOCs (surrogates for perchlorate) in samples from the landfill's eastern-most wells, the relatively low-level impacts identified in well N-9, and the absence of groundwater impacts at City of Rialto Well No. 3. In addition, such a pulsed release is expected to have required a hydraulic "driver" similar to the affect of the more recent aggregate wash ponds release. Since significant historical ponding has not been identified in the Former Bunker Area, the inference that a substantive historical release to groundwater has not occurred is reasonable.

RWQCB Statement:

> *"It is apparent that the presence of TCE, 1,1,1-TCA and 1,2-DCP in the monitoring wells, including the downgradient most monitoring well, N-10, is a result of a VOC plume emanating from the Unit 5 expansion area. "*

Response:

This assertion is unsupported. TCE has been associated with perchlorate operations at many sites throughout the country and was also detected in West Valley Water District Well No. 22, a well that the RWQCB suggests is not impacted by the Bunker Area release but rather a larger regional plume east of the Bunker Area. Since no exploratory wells have been constructed to better characterize the eastern plume, the assertion that these VOCs indicate a Bunker Area source is unsupported.

RWQCB Statement:

> *"It appears that infiltrating water, and probably the groundwater mounding associated with the ponds, may have hydraulically advanced some of the perchlorate cross gradient to the area of well N-1."*

Response:

While this assertion is possible, GLA's modeling results indicate that it is equally plausible that these impacts represent the western edge of the larger regional plume east of the Bunker Area plume.

RWQCB Statement:

> *"The data in the evaluation report are not sufficient to reasonably substantiate your conclusion that the plume emanating from the Unit 5 expansion area ends in the area of well N-9."*

Response:

GLA believes that, without additional analysis of the larger regional release, the conclusions provided in our report are a reasonable interpretation of the available data.

PROJECT WORK PLAN

INSTALLATION OF GROUNDWATER MONITORING WELLS IN RESPONSE TO RWQCB INVESTIGATIVE ORDER # R8-2003-0013 FOR INVESTIGATION OF PERCHLORATE AND VOLATILE ORGANIC COMPOUNDS IN GROUNDWATER

SAN BERNARDINO COUNTY, CALIFORNIA

1.0 INTRODUCTION

1.1 GENERAL

As directed by the Regional Water Quality Control Board – Santa Ana Region (RWQCB, letter dated January 15, 2004), the County of San Bernardino (County) is proposing to install additional groundwater monitoring wells and complete additional groundwater characterization in the vicinity of its Mid-Valley Sanitary Landfill (MVSL) in the City of Rialto, California. This Work Plan identifies the supplemental investigative work that the County proposes to perform to better characterize the distribution and source, or sources, of perchlorate and volatile organic compound (VOC) impacts to groundwater adjacent to the former Bunker Area east of the MVSL. This Work Plan does not supercede, but rather supplements, the original scope of work identified for the project (GeoLogic Associates, March 2003). As such, work tasks associated with the original Work Plan (such as preparation of a Bunker Area closure plan) are continuing.

As described herein, project work involves a field and laboratory program to better characterize the nature and extent of groundwater impacts in the area. Project work will include:

- Installation of up to 30 temporary and 6 permanent groundwater monitoring wells.
- Chemical analysis of groundwater samples obtained from the wells.
- Completion of 3 variable rate (step) and 3 twenty-four hour aquifer pumping tests.
- Monthly monitoring of monitoring wells constructed southeast of the former Bunker Area.
- Preparation of a Supplemental Perchlorate Investigation Report.

1.2 BACKGROUND

1.2.1 Perchlorate Impacts to Regional Municipal Production Wells

In 1997 and 1998, the Cities of Rialto and Colton, and West San Bernardino County Water District (now West Valley Water District [WVWD]), collected groundwater samples from their municipal supply wells in the Rialto-Colton Groundwater Basin. Perchlorate was measured at concentrations above 18 μg/L in five of the wells and a perchlorate concentration of over 700μg/L was measured in samples from WVWD No. 22, the well located closest to the former Rialto Ammunition Backup Storage Point (RABSP).

Owing to its age and impacted condition, WVWD subsequently converted Well No. 22 into a 2-stage monitoring well by constructing two separate sections of polyvinyl chloride (PVC) well screen separated by sealed solid PVC sections. This allowed for evaluation of perchlorate concentrations at two depths within the original well bore and yielded detection of perchlorate at concentrations as high as 820 μg/L.

1.2.2 Perchlorate Monitoring at MVSL Monitoring Wells

Monitoring for perchlorate in the vicinity of the MVSL was first conducted at all facility monitoring wells in October 1997. At that time, perchlorate was detected at only one well (F-6 at the southeastern corner of Unit 2; Figure 1) where a concentration of 4.2 μg/L (just above the laboratory's practical quantitation limit [PQL]) was measured. During the 11 quarterly monitoring events between October 1997 and July 2000, perchlorate was routinely tested for but detected at well F-6 just two more times. These detections were reported at only trace-level concentrations (i.e., below the laboratory's PQL). In July 2000 the perchlorate concentration in the sample from well F-6 was measured at 10 μg/L (significantly above the laboratory PQL) and by January 2001 it had risen to 250 μg/L. Since January 2001, perchlorate concentrations in samples from well F-6 have fluctuated between 56 and 300 μg/L.

Following the initial increase in perchlorate concentrations at well F-6, samples from well F-3 were again tested for perchlorate. Though no perchlorate was detected in the F-3 sample collected in January 2001, by April 2001 perchlorate was detected in well F-3 at 18 μg/L. Perchlorate concentrations then rose to a high of 48 μg/L in July 2001, after which it declined to a low of 17 μg/L just before the well went dry in January 2002.

Perchlorate has not been detected in any other County monitoring wells.

1.2.3 Recent Perchlorate Investigation

Following identification of perchlorate in monitoring well samples, the RWQCB issued Cleanup and Abatement Order No. R8-2003-0013 on January 17, 2003. In response to that Order, the County prepared Work Plan (March 2003) to investigate perchlorate impacts to soils and groundwater near the former Bunker Area, east of the MVSL. The groundwater components of the Work Plan were completed and a project report that was subsequently submitted to the RWQCB (GeoLogic Associates, October 2003). Earlier investigation included:

- Literature and aerial photograph review to identify potential sources of perchlorate impacts in the area.
- Excavation of 17 shallow exploratory soils borings within stockpiled bunker debris and associated soils at the Robertson's Ready-Mix aggregate processing plant located east of the former Bunker Area.
- Excavation of 5 deep exploratory soil borings within an accessible portion of the former Bunker Area.
- Installation of 57 temporary wells and 13 permanent groundwater monitoring wells upgradient, cross-gradient, and downgradient of the former Bunker Area.
- Development of a three-dimensional numerical groundwater model of the project area to simulate groundwater flow and contaminant transport conditions near the site and to evaluate alternative responses to groundwater impacts in the area.

Based on the results of the field and laboratory investigation, and as supported by the results of the numerical groundwater model that was prepared for the project, GeoLogic Associates tentatively concluded that:

- The detection of only trace concentrations of perchlorate and the absence of explosives in samples collected from bunker debris suggests that soils stockpiled at the Robertson's Ready-Mix plant do not pose a significant threat to water quality in their current condition.
- While the soil samples that were collected from beneath the former Bunker Area also failed to identify significant concentrations of perchlorate, the historical use of the property and detection of elevated concentrations of perchlorate in groundwater beneath the former Bunker Area suggests that soils in this area could contain elevated concentrations of perchlorate.
- Groundwater downgradient of the former Bunker Area has been impacted by elevated concentrations of perchlorate and a variety of VOCs. Perchlorate concentrations in temporary wells were as high as 820 μg/L at well F-6A, 710 μg/L at well N-5, 350 μg/L at well N-3, and 267 μg/L at well N-8 (Figure 1). Within permanent wells, perchlorate was measured at concentrations as high as 1000 μg/L at well N-3 (currently only 100 μg/L), 530 μg/L at well N-5, and 310 μg/L at well N-8. The most commonly detected VOC was trichloroethene, which was found at concentrations that commonly exceeded its maximum contaminant level (i.e., > 5 μg/L).

- The spatial distribution of perchlorate impacts suggests that the 1999 perchlorate release to groundwater from the former Bunker Area is relatively restricted and does not extend more than about 4000 feet to the southeast (downgradient). Perchlorate-related impacts that have been identified in municipal production wells in the region do not appear to be associated with the Bunker Area release.

1.2.4 Additional RWQCB Requirements

Following submittal of the investigation results, the RWQCB presented comments regarding the report to the County (letter January 15, 2003). The most significant issues raised by the RWQCB with regard to the soil and groundwater characterization included:

- The RWQCB agreed that no information exists to suggest that the MVSL itself is responsible for perchlorate impacts to groundwater in the area.
- Owing to the relative absence of perchlorate in soil samples obtained from bunker area debris stockpiled at the Robertson's Ready-Mix plant, this phase of the investigation is considered complete.
- Recognizing the detection of low concentrations of perchlorate and VOCs in soil samples collected within the eastern portion of the former Bunker Area, and considering the detection of elevated perchlorate concentrations in select groundwater samples obtained in this area, the County may be required to conduct further soil and groundwater investigations. These studies may occur as part of any "closure" work required by the California Department of Toxic Substance Control.
- The RWQCB ordered that a Work Plan be submitted for further characterization of impacted groundwater conditions. The RWQCB Order requires that the Work Plan include provisions for installation of 5 additional groundwater monitoring wells to better delineate the limit of perchlorate impacts.
- Noting the disparity between hydraulic parameters included in a U.S. Geological Survey numerical model of the Rialto-Colton Basin and the values included in GeoLogic Associates' numerical model of the area downgradient of the former Bunker Area, the RWQCB concluded that GeoLogic Associate's model requires further verification to determine the downgradient extent of the contaminant plume.
- In order to develop a groundwater model for the perchlorate and VOC plumes in the immediate vicinity of the former Bunker Area, and possibly to extend the model to include other impacted wells within the Rialto-Colton Basin, the RWQCB also directed the County to submit a second Work Plan for development of a "conceptual groundwater model".

This Work Plan addresses the RWQCB's request for additional groundwater characterization. The RWQCB's request for development of a "conceptual groundwater model" of the project area is being submitted as a separate Work Plan.

1.3 GEOLOGIC SETTING

The MVSL is located near the northern end of the Peninsular Ranges Geomorphic Province near its junction with the Transverse Ranges Geomorphic Province. This area of southwestern San Bernardino County is underlain by several fault-bound structural blocks, including the down-dropped San Bernardino Valley Block located between the San Andreas and San Jacinto Faults; and the down-dropped Perris Block between the Elsinore Fault to the west, the Cucamonga Fault to the north and the San Jacinto Fault to the east (Fife et al., 1976). The MVSL is located in the northeastern portion of the Perris Block.

The landfill site is underlain by a considerable thickness of Quaternary alluvium overlying the Mesozoic basement complex. The maximum thickness of alluvium in the area is estimated to be greater than 900 feet near the Kaiser Steel Plant, approximately 6 miles southwest of the site (Fife et al., 1976). Unconsolidated Quaternary gravels, sands, silts, and clays associated with alluvial fan deposits (Qf) are exposed throughout the area and relatively recent channel deposits are present in all of the local unimproved drainages. Water well data in the vicinity suggests that some continental Tertiary deposits may be present between the Quaternary and older underlying Mesozoic units, though no local exposures of these materials have been identified. The basement complex underlying the alluvium and exposed in the San Gabriel Mountains north of the site consists of granitic and metamorphic rocks.

The site is located within a tectonically active region and several active faults exist within 30 miles of the property. These include faults of the San Andreas, San Jacinto, Cucamonga, Glen Helen, and Whittier-Elsinore Fault zones. The nearest active faults in the area are the San Jacinto Fault, located 2.6 miles to the northeast of the site and the Cucamonga Fault Zone located about 2.3 miles to the northwest. No known active or potentially active faults have been located on the property.

1.4 HYDROGEOLOGIC SETTING

1.4.1 Regional Setting

The MVSL is located within the northwest portion of the Rialto-Colton groundwater basin (Dutcher and Garrett, 1963). Groundwater flow in the basin is controlled by several barriers and faults that have been identified; some of which delineate the lateral boundaries of the basin. The Rialto-Colton Basin extends from Barrier J on the northwest to the Santa Ana River on the southeast (Figure 2). On the northeast it is bounded by the San Jacinto Fault, which separates the basin from the Lytle and Bunker Hill Basins. On the southwest it is separated from the Chino Basin by the

Rialto-Colton Barrier and by Barrier H. Dutcher and Garrett (1963) have presented evidence to indicate that inflow to the northwest portion of the basin is almost exclusively by leakage through Barrier J, with only a minor contribution from precipitation and infiltration. Recent work by the U.S. Geological Survey (Woolfenden, 1998) indicates that significant underflow may also occur across the northern portions of the San Jacinto Fault where it is coincident with Lytle Creek. South of this area, underflow across the San Jacinto Fault (Barrier E) is relatively limited. On the west side of the basin, the northern portions of the Rialto-Colton Barrier impedes groundwater flow.

Although some investigators of the basin doubt that Barrier H exists (Fox and Roberts, 1995), Dutcher and Garrett (1963) identified Barrier H as a sub-parallel feature of the Rialto-Colton Fault. Fontana Union Water Company (FUWC) wells F-10A and F-10B are located near the junction of the Rialto-Colton Fault, Barrier H, and an unnamed barrier first identified by the California Department of Water Resources that extends northwest toward the MVSL (CDMG, 1970).

Groundwater in the Rialto-Colton Basin occurs within alluvial sediments at depths ranging from more than 400 feet below ground surface (bgs) northeast of the site to less than 100 feet bgs closer to the mountain front. Near the Santa Ana River groundwater is even shallower (Figure 2). Water well data suggests that groundwater in the northern and central portions of the Rialto-Colton Basin flows to the south and southeast under an average gradient of about 0.02 to 0.04 ft./ft (Woolfenden and Kadhim, 1997).

U.S. Geological Survey studies of the Rialto-Colton Basin identified three hydrologic units (Woolfenden and Kadhim, 1997) in the project area. The upper unit is saturated only in areas adjacent to active watercourses such as Lytle Creek and the Santa Ana River. Near the MVSL, the middle unit is saturated and yields water to municipal supply wells. At depths below about 600 to 700 feet, the lower unit yields smaller volumes of water.

1.4.2 Local Conditions

Groundwater investigations completed near the MVSL (GLA, 1997a, 1997b, 2003) have identified three laterally-continuous aquifers within what Woolfenden and Kadhim (1997) first identified as the Rialto-Colton Basin's middle hydrologic unit. These include an upper unconfined aquifer (hereafter the Upper Aquifer) that occurs at depths of about 245 to 340 feet below ground surface, an intermediate partially confined aquifer (hereafter, Intermediate Aquifer), and a deep regional confined aquifer (hereafter, Regional Aquifer) that provides much of the groundwater that is pumped in the area by municipal supply wells. The three aquifers are separated by laterally continuous, relatively low-permeability aquitards that generally range in thickness from only a few feet to over 30 feet (Figure 3).

Groundwater in each of the aquifers occurs in sandy gravels, gravelly sands, and sands that typically have excellent water-bearing and water-yielding properties. Drilling and well installation data suggest that the three aquifers are laterally continuous with a downward hydraulic gradient between the individual units. While the Upper Aquifer had a saturated thickness of about 15 to 35 feet between 1996-1998 (GLA, 1997b, 1998), regional drought conditions have resulted in dewatering of much of the unit today. As a result, the uppermost groundwater that was consistently encountered in the recent investigation was identified in the Intermediate Aquifer.

In the project area, the Intermediate Aquifer is about 40 to 140 feet thick and its potentiometric surface typically extends above the top of the overlying aquitard. As discussed below, the Intermediate Aquifer actually consists of a number of smaller water-bearing units that are separated by relatively thin (e.g., < 5 feet thick) aquitards with a downward hydraulic gradient between the subunits. In the upper portion of the Intermediate Aquifer, the downward hydraulic gradient is typically less than a few feet while, at depth, the downward gradient was measured to be as much as 65 feet. A significantly thicker aquitard (the Regional Aquitard) separates the Intermediate Aquifer from the Regional Aquifer and a substantial downward hydraulic gradient exists between these two units. This hydraulic gradient is almost 100 feet across the aquitard, and as much as 170 feet between the uppermost groundwater unit in the Intermediate Aquifer and the Regional Aquifer.

Though the full thickness of the Regional Aquifer was not penetrated by the project wells, data presented by Woolfenden and Kadhim (1997) indicate that in this area of the Rialto-Colton Basin the Regional Aquifer may extend 150 feet beyond the base of the Regional Aquitard. Below this depth, the "lower groundwater unit" and consolidated Tertiary marine sedimentary deposits are expected to yield significantly smaller volumes of groundwater.

Groundwater elevations are measured routinely in monitoring wells near the MVSL (GLA, 1992-2003). These data indicate that groundwater elevations at the site have dropped as much as 58 feet within the past 4 years, though groundwater equipotential plans developed from MVSL monitoring data consistently indicate a southeasterly groundwater flow direction in the local Upper, Intermediate, and Regional Aquifers. Measured gradients are generally consistent with the regional gradients identified by the U.S. Geological Survey (Woolfenden and Kadhim, 1997).

The results of aquifer tests completed for the Phase I VOC EMP (GLA, May 1997a) and the results of tests completed for the recently completed perchlorate investigation (GLA, 2003) indicate that the hydraulic conductivity of the Upper and Intermediate Aquifer materials in the project area are similar and range from about 10 to 60 feet/day. Literature review suggests that the porosity in both aquifers should be approximately 20 to 35 percent (Driscoll, 1986). Based on these values and the average hydraulic gradient measured in the area (about 0.018 ft/ft), the groundwater velocity in the project area is estimated to be approximately 1 to 5 feet per day.

2.0 PROPOSED SCOPE OF WORK

2.1 GENERAL

This Work Plan identifies procedures and protocols that will be followed during construction and analyses of up to 30 temporary wells and 6 permanent monitoring wells that will be installed southeast of the former Bunker Area. Following RWQCB approval of the results of this investigation, the Engineering Evaluation that is being completed for this project (GLA, February, 2004) will be updated to identify corrective action measures that could be implemented on and downgradient of the site.

2.2 FIELD & LABORATORY INVESTIGATION

The field and laboratory investigation proposed herein will focus on better defining the distribution and extent of perchlorate and VOC impacts that have been associated with the former Bunker Area. Investigative work will include the following major tasks:

- Installation of 1 "replacement" groundwater monitoring well (N-9B) adjacent to existing monitoring well N-9 (Figure 1).
- Construction of 3 groundwater monitoring wells (N-11, N-12 and N-13) downgradient of existing monitoring well N-10.
- Installation of 2 groundwater monitoring wells (N-14 and N-15) east of existing monitoring wells N-1 and N-6.
- Three variable-rate and 3 constant-rate aquifer pumping tests.
- Monthly monitoring of "N series" wells that have been constructed southeast of the former Bunker Area.

As described in the following sections, each of the 6 new groundwater monitoring wells will be drilled using air-rotary casing hammer (ARCH) drilling techniques (or equivalent) and "temporary" groundwater monitoring wells will be installed in discrete hydrostratigraphic intervals as drilling progresses. Project boreholes will extend through the Upper Unconfined and Intermediate aquifers to the deep "Regional" aquifer (675-foot maximum anticipated depth). After review of the temporary well analytical results, permanent 4-inch diameter monitoring wells will be installed in the most highly impacted zones, and 2-inch diameter piezometers will be installed and isolated within the deep Regional Aquifer in four of the six boreholes. Proposed wells N-9B will not include a separate piezometer since the existing well N-9B deep piezometer is still functional. In addition, since proposed well N-11 will be designed with 5-inch diameter well casing so that relatively high-discharge rate aquifer pumping tests may be performed, there will not be enough room in this borehole to install the deep piezomenter.

As indicated above, 2 relatively high discharge-rate (e.g., ~30 gallons per minute [gpm]) aquifer pumping tests, and one moderate-rate (e.g., ~10 gpm) pumping test will be performed to better characterize the hydraulic properties of aquifer materials in the project area. Each aquifer test will include variable-rate pumping stress periods to identify optimal pumping rates for subsequent 24-hour constant-rate aquifer pumping tests.

2.2.1 Replacement Well N-9B

As detailed in the earlier perchlorate investigation report (GLA, October 2003), monitoring well N-9 was constructed within the fourth hydrostratigraphic interval sampled during drilling (between 460 and 472 feet below grade), in a well-graded gravelly sand unit. While sufficient groundwater was identified in this interval to permit temporary well sampling, following installation of the permanent monitoring well, groundwater levels quickly declined and the well is now dry. Geophysical inspection of well N-9 indicated that this anomalous condition is similar to unsaturated aquifer conditions identified for the upper portion of the Regional Aquifer in wells N-3, N-4, N-7, and N-8.

Since the 2-inch diameter Regional Aquifer piezometer at well N-9 continues to be functional, the N-9B replacement well will include only a 5-inch diameter Intermediate Aquifer monitoring well. The high discharge-rate aquifer pumping test that will be completed at well N-9B will permit both better definition of aquifer hydraulic properties and an assessment of hydraulic communication across the aquitard that separates the Intermediate and Regional aquifers.

2.2.2 Installation of Well N-11, N-12 and N-13

Wells N-11, N-12 and N-13 will be installed approximately 1200 to 2400 feet southwest, south, and southeast of existing well N-10 (Figure 1). While the County does not regard the impacts that have been identified at Well N-10 as having originated from the former Bunker Area, installation of these three new monitoring wells will permit better delineation of perchlorate and VOC impacts in the area.

Since groundwater impacts appear to move progressively deeper with distance from the interpreted source(s) east and northeast of the MVSL, wells N-12 and N-13 will be constructed with both a 2-inch diameter Regional Aquifer piezometer and a 4-inch diameter Intermediate Aquifer monitoring wells. Well N-11 will be constructed using 5-inch diameter well casing to allow for completion of a high discharge-rate aquifer pumping test.

2.2.3 Installation of Wells N-14 and N-15

In order to better define the eastern limits of impacts associated with the former Bunker Area, wells N-14 and N-15 will be installed approximately 500 to 1000 feet east of existing wells N-1 and N-6 (Figure 1). Both wells will be equipped with 2-inch piezometers in the Regional Aquifer and 4-inch diameter monitoring wells in the most highly impacted Intermediate Aquifer zone. In order to optimize the location of these wells, they will be constructed taking into account the groundwater information that becomes available from the other new County wells and new wells to be installed by other potentially responsible parties.

2.3 WELL CONSTRUCTION

2.3.1 Access for Well Construction

Since it is expected that authorization for well construction will be most expeditiously completed in agreements with the City of Rialto, wherever possible the proposed wells will be located within roadway easements. It is anticipated however that access agreements will be required from CalTrans for well N-9B. The specific locations of the monitoring wells will be identified following discussions with RWQCB staff and City officials and will take into account the relative ease of access to proposed drilling locations.

2.3.2 Well Configurations

As indicated on Tables 1 and 2 below, both temporary and permanent groundwater monitoring wells will be constructed, and piezometers will be included in 4 of the project boreholes.

Table 1
Temporary Well Design Summary

Borehole Diameter	10 inch (minimum)
Well Casing Diameter	2-inch
Casing Material	SCH. 80 PVC
Screened Interval	5 feet
Screen Material	SCH. 80 PVC with 0.020-inch slots
Filter Pack	#3 Monterey
Intermediate Well Seal	Bentonite Chips
Intermediate Seal Thickness	5 to 10 feet
Well Seal	None

As summarized on Table 2, four (4) permanent groundwater monitoring wells (with separate 2-inch diameter piezometers) will be installed to a maximum anticipated depth of approximately 675 feet. The two (2) remaining permanent wells will be installed without the 2-inch diameter piezometer, but will include 5-inch diameter well casing. The actual depth of the permanent wells will be determined following review of laboratory analytical data for groundwater extracted from the "temporary well" samples obtained from each borehole, and after discussions with the RWQCB.

Table 2
Permanent Well Design Summary

Screened Interval	Variable (10 to 50 feet)
Borehole Diameter	10 inch (minimum)
Well Casing Diameter	4-inch (4 wells); 5-inch (2 wells)
Piezometer Casing Diameter	2-inch (4 wells); NONE (2 wells)
Casing Material	SCH. 80 PVC
Screen Material	SCH. 80 PVC with 0.020-inch slots
Filter Pack Material	#3 Monterey

Table 2 (continued)

Intermediate Well Seal (above sand)	Bentonite Chips (no pellets) 10 feet (min.) thick
Well Seal	Neat cement (Type I/II) with 5% bentonite
Surface Improvements	3-foot x 3-foot by 4-inch concrete pad. 8-Inch diameter, lockable, steel riser. Four 3-inch diameter, concrete-filled traffic control bollards.*

* - At the County's direction, riser may be replaced by traffic-rated "cristy box"

2.3.3 Drilling Methods

Decontamination - Other than factory decontaminated and plastic wrapped well casing and screen and disposable bailers, all materials entering the borehole or wells will be decontaminated. Decontamination will be accomplished using a stiff brush, steam-cleaner and non-phosphate detergent, followed by a double rinse using potable water.

Decontamination of the drill rig and equipment before initial drilling and between borings will be performed at a location at the landfill approved by the County or its representative. At this location, the well contractor (WC) will establish a decontamination "pad" where all decontamination waters will be contained and collected on visqueen sheets. All decontamination waters will be transferred from the sheeting to drums for later disposal. The WC shall also provide racks to enable thorough cleaning of drill rods and equipment. Following decontamination, drill rods will be allowed to air dry on the racks before transport to the new drilling location. Any decontaminated materials that are not utilized within one-half day shall be wrapped in plastic in preparation for later use.

Borehole Drilling - All drilling and well construction operations will be completed in accordance with procedures approved by the San Bernardino County Department of Environmental Health Services and listed in California Department of Water Resources (DWR) Bulletin 74-90. Drilling will be accomplished using Dual-Wall, Reverse Circulation, Percussion Hammer (Reverse Circulation); Air Rotary Casing Hammer (ARCH); or equivalent drilling methods. These methods are acceptable provided that:

- Casing separates the borehole from native materials to the full depth of the borehole.
- Drilling fluids (mud or foam) may not be utilized.
- If required by drilling conditions, potable water may be injected in a "misting" manner with the prior approval of the geologist and providing that the WC demonstrates by approved laboratory analyses (EPA 601/602 and EPA 314.0) that the water source and storage vessel are suitable for this purpose.
- The drilling air source is equipped with an approved filter.
- The WC provides SWMD or its representative with approved containers to store drill cutting samples which will be retained at 5-foot intervals.

A temporary borehole protective cover of steel sheeting will be placed on the entry hole during any breaks in the drilling process. In the event that a borehole needs to be abandoned during the drilling program, the hole will be sealed by placement of a neat cement slurry (with 5 percent bentonite by weight) using tremie pipe and positive displacement techniques.

Once drilling has proceeded to about 20 feet above the anticipated depth to first groundwater, the borehole will be allowed to equilibrate for a period of not less than 30 minutes to allow water to enter the hole. This equilibration protocol will be conducted on subsequent ten-foot vertical intervals until first water is identified.

Soil Sampling - Soil grab samples will be obtained from the drill cyclone separator at 5-foot vertical intervals, or whenever a change in lithology is noted, through the entire depth of the borehole.

Cuttings Disposal - Dry drill cuttings shall be collected and transported by the WC to a location at the MVSL that has been approved by the County. Drill cuttings returned to the surface from below groundwater will be collected, transported to and stored in WC provided Baker tanks (or equivalent) or WC constructed visqueen-lined disposal basins at a location at the landfill property that has been approved by the County or its representative. The visqueen disposal areas shall be large enough to accommodate the wet cuttings delivered from the boreholes, and to permit these materials to dry out. Once the wet cuttings have dried sufficiently, these soils will be placed within lined portions of the landfill.

Disposal of Waters Generated During Drilling - Large amounts of water may be generated during drilling, installation, development and aquifer pumping tests of the wells. Due to the possible presence of contaminants in groundwater, all waters generated during the project shall be stored in temporary storage tank(s) (e.g., Baker Tanks) and then disposed in a legal manner at an offsite location with appropriate documentation thereof.

2.3.4 Borehole Logging

All drilling operations will be continuously observed and all samples, drill cuttings and changes in drilling conditions will be logged by the on-site geologist. Boring logs will be prepared for each well boring, and will include descriptions for the following items:

- Borehole designation and location.
- Times and dates that drilling-excavation began and ended.
- Type of drilling equipment used, including manufacturer, make, and model for any special modifications.
- Name(s) of geologist(s) responsible for log description.
- Name(s) of other personnel assisting in the logging.
- Description of soils according to the Unified Soil Classification System (including Munsell Soil Color identification) and accepted geologic nomenclature.

- Systematic descriptions of lithologic and structural changes in strata or soil horizons including thickness of units, as well as depth and elevation of changes.
- Presence and depth of groundwater.
- Caving or sloughing conditions in the hole including depth and elevation.
- Sampling interval(s), including depths and elevations.
- Any unusual color, staining, or odors of chemical or waste origin.
- Drilling advancement in feet per hour (average) and/or feet per minute, noting any periods of difficult or very easy drilling.
- Any subsurface structures or unusual features encountered.
- An opinion as to the characteristics and permeabilities of water-bearing lithologies.
- Other notes and descriptions as appropriate.

2.3.5 Borehole Geophysical Surveys

Owing to well construction requirements and the presence of steel drive-casing in the boreholes, the only geophysical method that is expected to provide useful lithologic and hydrologic data is the dual-induction gamma-ray method. This method will be employed at each of the project borings once the borings have reached target depths (i.e., once the borehole has been advanced to the deep Regional Aquifer and a groundwater sample has been obtained).

2.3.6 Well Installation

All well construction practices will be in accordance with the California Well Construction and Abandonment Procedures (DWR Bulletin 74-90), and with well construction standards established by the San Bernardino County Department of Environmental Health Services.

Well Materials – Well materials shall consist of the following:

- Well casing and screen will be virgin, decontaminated and factory-sealed well materials.
- All well materials shall be covered with plastic when delivered on site and shall remain covered until used in construction.
- Four (4) of the six (6) permanent groundwater monitoring wells will be constructed using 4-inch I.D. Schedule 80 PVC casing in 10-inch (minimum) diameter boreholes. Well screens shall also be 4-inch I.D. Schedule 80 PVC (Figure 4) with the screen length to be determined on the basis of the lithologic conditions observed in the borehole.
- Two of the permanent groundwater monitoring wells will be constructed using 5-inch I.D. Schedule 80 PVC casing in 10-inch (minimum) diameter boreholes. Wells screens shall also be 5-inch I.D. Schedule 80 PVC (Figure 5) with the screen length to be determined on the basis of the lithologic conditions observed in the borehole.

- Piezometers will be constructed in the same boreholes that the 4-inch I.D. permanent monitoring wells are installed and shall be constructed using 2-inch I.D. Schedule 80 PVC with 10-foot-long screen sections.
- Temporary wells will be constructed using 2-inch I.D. Schedule 80 PVC with 5-foot-long screen sections.
- Well screen shall be slotted in the factory at widths appropriate to the screened formation and filter pack (anticipated to be 0.02-inch).
- All casing and screens will be flush-threaded, and a threaded bottom plug will be placed at the base of the wells. No glue or solvents will be used to join the pipe sections.

Installation Methods - The annulus around the screen interval will be filled with the appropriate filter pack, using tremie placement techniques, and the sand will be surged and settled to the satisfaction of the County or its representative concurrent with placement. Filter packs will consist of commercial washed and graded sands. Permanent well filter packing will extend from one foot below the bottom of the screened interval to a minimum of two feet above the screened section. Temporary well and piezometer filter packing will extend from one foot below the bottom of the screened interval to one foot above the screened section. Depth soundings will be performed to evaluate the thickness and uniformity of the sand pack and to assure that no bridging occurs.

For permanent wells, a minimum 10-foot thick, hydrated, granular bentonite seal (chips or pellets) shall be placed above the filter pack. For piezometers, a minimum 5-foot thick, hydrated bentonite seal (chips or non-time released pellets) shall be placed above the piezometer filter pack. A minimum 30-foot thick hydrated, granular bentonite seal (chips or non-time released pellets) shall be placed below the permanent well filter pack (Figure 4). If above the groundwater table, the bentonite will be hydrated after placement using a minimum of 20 gallons of water introduced after every 2.5-foot of bentonite placement. After introduction of the water, the bentonite seal will be allowed to hydrate for a period of not less than one-half hour prior to placement of overlying slurry seal materials. Depth soundings will be performed to evaluate the thickness and uniformity of the bentonite seal and to assure that no bridging occurs.

For permanent wells, the remaining annulus of the borehole above the hydrated bentonite seal will be sealed with a neat cement (with 5 percent bentonite by weight) slurry seal. The annulus slurry seal materials will consist of commercial well sealing cement (Portland Type I/II) and bentonite, and have a water to cement ratio that includes no more than 8 gallons of water per sack of cement.

Well Head Security - Following permanent well installation and well development, a temporary lockable cover will be placed to secure the well. Eight-inch diameter steel conductor casing will be placed over the top of the permanent well casing and a 3x3-foot by 4-inch thick concrete pad will be constructed around the well casing. Four (4) 3-inch diameter, concrete-filled traffic control ballards will be installed at its corners and one of the ballards will be installed within 4-inch diameter steel sleeve to allow for later removal of the ballard and access to the well by service equipment.

Well Development - After tremie placement of the sand pack and prior to placement of the bentonite chips, all wells and piezometers will be pre-developed using bailing or surging techniques to settle the sand pack and remove fines. The level of the sand pack within the annulus will be measured both before and after the predevelopment process, and additional sand will be added to the borehole to bring the sand pack to design elevations.

Following construction, annular grout will be allowed to cure for a minimum of 24 hours prior to final well development. At that time the wells will be developed using a bailer and surge block and by pumping and surging with a well development pump until visually clear water ($\pm$ 20 NTU) is discharged from the well, and the temperature, pH, and specific conductivity of discharge water stabilizes.

Well development records will be recorded on a Well Construction Summary log, and will include the following information:

- Name of sampler.
- Total depth of well, casing diameter, and well volume.
- Starting groundwater level.
- Time log of groundwater removal, general clarity, temperature, pH, and electrical conductivity.
- Total well volumes removed.
- Sample pump flow rate.
- Time of sample acquisition.
- Final depth to water.

2.4 WELL SAMPLING

2.4.1 <u>Temporary Well Sampling</u>

To minimize the potential for groundwater mixing between adjacent water zones, and in order to optimize the likelihood of collecting a discrete and representative groundwater sample, water zones encountered beyond first water will be sampled using "temporary" wells. Temporary wells will be constructed in much the same way that permanent wells are constructed (see above) including well casing with screen, filter pack placed adjacent to well screen, and a bentonite seal. The bentonite seal will be placed so that they extend to the overlying aquitard materials penetrated during drilling, thus isolating the sampling interval.

After allowing the bentonite seal to hydrate for about one hour and after sounding the well to determine the depth to groundwater, each temporary well will be purged using a decontaminated stainless or galvanized steel bailer. After removing a minimum of three borehole volumes of groundwater, a water quality sample will be collected from the temporary well using new factory-sealed disposable polyethylene bailers (i.e., one bailer per sample).

Sample waters will be decanted directly from the bailers into laboratory-prepared vessels appropriate to the laboratory testing method. Volatile samples will be collected first using a disposable low-flow bottom emptying port that minimizes volatilization. Non-volatile samples will collected after volatile samples. The collected samples will be placed immediately on ice in a thermally insulated cooler for transport to the laboratories. A completed chain-of-custody form detailing the sample identification (ID) numbers, dates and times collected, analyses requested and project information will accompany each sample to the laboratory. The chain-of-custody forms will be signed and dated by all personnel retaining custody of the samples.

2.4.2 Permanent Well Sampling

Following development of the permanent wells, the following sampling protocols will be adhered to during sampling:

- Upon arrival at each monitoring well, the wellhead will be inspected for evidence of tampering and/or vandalism.
- Prior to sounding, a weighted water level indicator (Solinst 100 Water Level Meter or Slope Indicator Water Level Indicator) will be decontaminated using a non-phosphate detergent (Alconox®) and water solution. The initial water level and total depth of water within each well will then be sounded to the nearest 0.01-foot relative to the top of casing using the weighted water level indicator. The sounding results will be recorded on a well data sheet.
- Based on the calculated storage volumes within the casing and filter pack, a minimum of three borehole and casing volumes will be purged from the wells using decontaminated stainless steel or galvanized bailers.
- Wells will be purged from the top of the water column at a rate consistent with the production rate of each well.
- Well indicator parameters (pH, temperature, electrical conductivity, and turbidity) will be measured at regular intervals during purging operations to verify that fresh water is entering the well. Once the appropriate volumes have been purged and the indicator parameters have stabilized, the wells will be sampled using clean factory-sealed disposable polyethylene bailers.
- Sample waters will be decanted directly from the bailers into laboratory-prepared vessels appropriate to the laboratory testing method. Volatile samples will be collected first using a disposable low-flow bottom emptying port that minimizes volatilization. Non-volatile samples will collected after volatile samples.
- The collected samples will be placed immediately on ice in a thermally insulated cooler for transport to the laboratories.
- A completed chain-of-custody form detailing the sample identification (ID) numbers, dates and times collected, analyses requested and project information will accompany each sample to the laboratory. The chain-of-

custody forms will be signed and dated by all personnel retaining custody of the samples.

2.5 LABORATORY ANALYSES

All laboratory analyses will be performed by an analytical laboratory that has been certified by the state for the test method to be employed.

Recognizing that the new groundwater monitoring wells will be installed at distance from the interpreted source, and considering the absence of contaminants in borehole soil samples retained previously for the project, laboratory analyses will focus solely on groundwater samples. All samples will be evaluated for the following:

- Volatile Organic Compounds (VOCs) – EPA Method 8260
- Perchlorate – EPA Method 314.0

Laboratory quality assurance / quality control will include method analyses (as required by laboratory certification), trip blanks, field blanks, and duplicates. Trip and field blanks will analyzed for VOCs only. One trip blank and one field blank will be obtained for each "batch" of samples delivered to the laboratory (i.e., for VOCs and Perchlorate). One duplicate sample will be obtained from one temporary well sampling interval within each borehole.

2.6 AQUIFER PUMPING TESTS

2.6.1 Test Locations

Aquifer testing will be performed at wells N-9B, N-11, and N-15 (Figure 1). Since wells N-9B and well N-11 will be constructed using 5-inch diameter well casing, relatively high discharge-rate (e.g., 20 to 40 gpm) tests will be completed at these wells. Since groundwater head monitoring in the deep Regional Aquifer is expected to provide valuable information at the N-15 location, this well will be constructed using 4-inch casing to allow for inclusion of a 2-inch diameter piezometer. The smaller permanent well diameter will allow not allow for placement of a larger pump and as a result, this well will be stressed at relatively low pumping rates (e.g., about 10 gpm).

2.6.2 Test Methods

To obtain a better understanding of the hydraulic characteristics of aquifer materials in the project area, 3 aquifer pumping tests will be performed following installation of permanent wells. Each of the 3 tests will include a 5-step variable discharge-rate pumping analysis (i.e., step-test) and a 24-hour constant rate pumping test. Electric submersible pumps will be installed in each test well, and power will be supplied by a portable generator. Constant pumping rates will be maintained, as appropriate to individual tests, using electrical pumping controls or discharge pipe valves, as needed. Pumping rates will be continuously monitored using digital flow meters or totalizers. The accuracy of the flow metering equipment will be periodically checked by mechanical means (i.e., timed discharge to a vessel of known volume).

Prior to the initiation of any test, calibrated pressure transducers connected to a surface data logger will be placed in the test well and any observation well (such as well N-9) and they will remain in the wells for the duration of the test. Water pumped from the well will be discharged temporarily to holding tanks before it is hauled off for appropriate disposal. After 24 hours, the pump will be turned off and the data loggers will record aquifer recovery for 24 hours. Pumping test data will then be downloaded and analyzed using recognized analytical techniques and software to assess the hydraulic properties of aquifer materials (i.e, Transmissivity, hydraulic conductivity, storativity, and specific yield) and to assess the possible presence of local hydrogeologic anomalies.

2.7 MONTHLY GROUNDWATER MONITORING

Wells constructed for this supplemental investigation and wells that were previously installed to investigate perchlorate impacts downgradient of the former Bunker Area (i.e., "N series" wells) will be sampled monthly for a period of six months following construction of the sixth well described herein. Laboratory testing will include perchlorate and VOCs, and will include quality assurance / quality control measures as described above.

2.8 REPORT OF FINDINGS

Following completion of the field and laboratory investigation described above, a Supplemental Investigation of Perchlorate Impacts report will be prepared and submitted to the RWQCB. The report will detail the methods, materials and results of the well construction, sampling, and aquifer testing program. Specifically, the report will include the following:

- Discussion of methods used to drill, construct and sample monitoring wells and to complete aquifer pumping tests.
- Discussion of lithologic and hydrostratigraphic information obtained from each borehole.
- Drafted boring and well completion summary logs.
- Tabulated laboratory analytical results with attached certificates of analysis.
- Tabulated aquifer testing results with attached computer analyses of water elevation response data.
- Updated geologic cross-sections that depict the configuration of aquifers and aquitards that are encountered in the borings, and which relates the new hydrostratigraphic information to previous study of the project area.
- Groundwater equipotential plans for the Intermediate and Regional Aquifer that integrate water elevation data from time periods that are as close together as possible.

- Mass load analyses to enable depiction of the distribution of perchlorate and VOC impacts downgradient of source areas.

3.0 PROJECT SCHEDULE

The anticipated schedule for completing the work described above is presented below. Although every effort will be made to keep the project schedule "on track", it is possible that well access authorization difficulties and drill rig availability could delay well installation activities.

The following milestones in the proposed schedule are critical to the prompt completion of the project work:

- Solicitation of Well Contractor Bids – March 1, 2004
- Award of Drilling and Well Construction Contract – April 2, 2004
- Installation of Well N-9B - April 16, 2004
- Installation of Wells N-11, N-12 and N-13 - May 21, 2004
- Installation of Wells N-14 and N-15 – June 25, 2004
- Three Aquifer Pumping Tests – Submitted by July 16, 2004.
- Report of Findings – Completed by August 13, 2004.

4.0 CLOSURE

This Work Plan is based on the data summarized described above and included in the references made herein. GeoLogic Associates should be notified of any conditions that differ from those described herein since this may require a re-evaluation of the work-plan elements presented. This Work Plan has not been prepared for use by other parties and projects other than those named or described above. It may not contain sufficient information for other parties or other purposes.

GeoLogic Associates

Gary L. Lass, C.E.G., C.H.G
President

Attachments: Figures 1 through 5

5.0 REFERENCES

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FIGURES

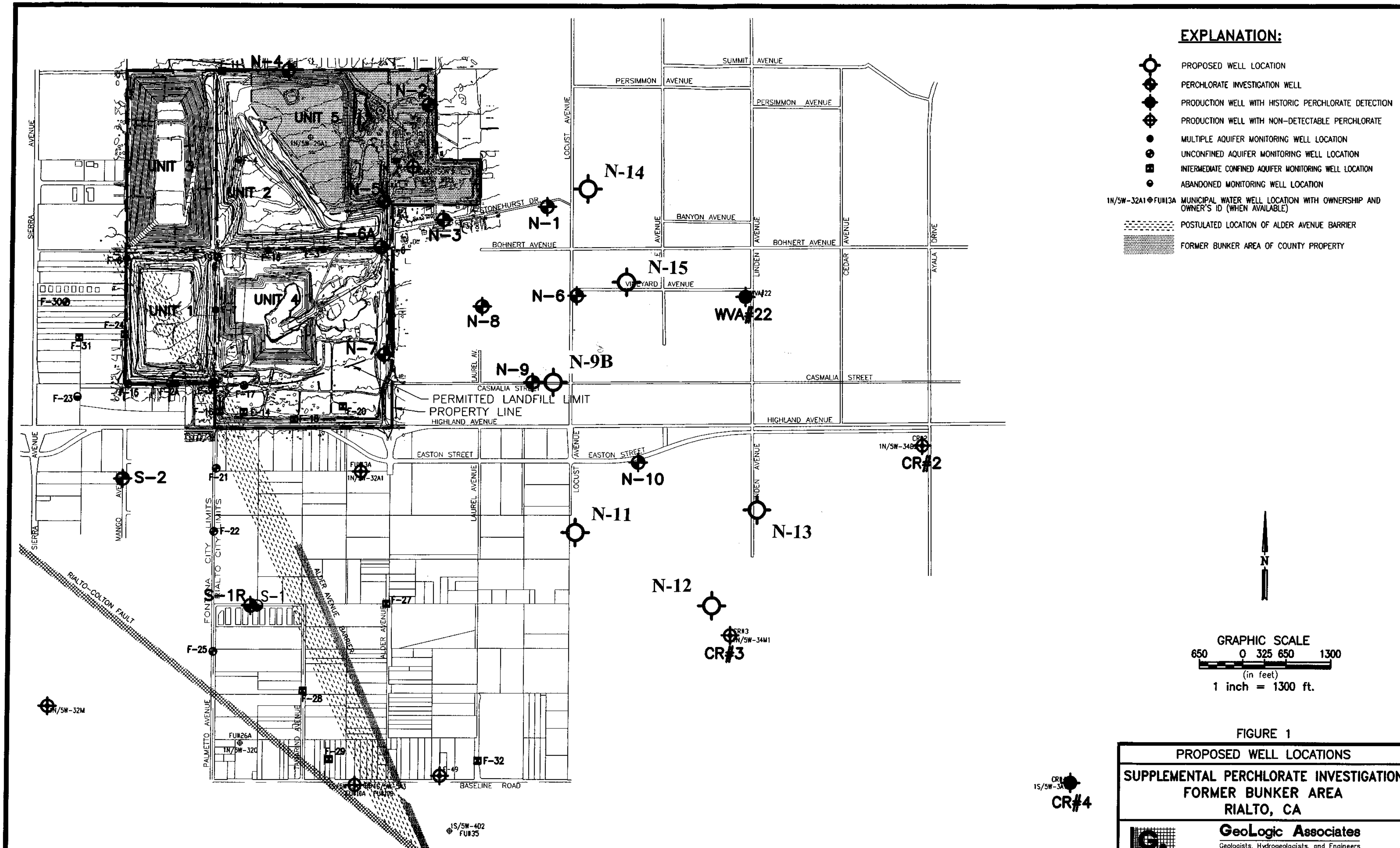
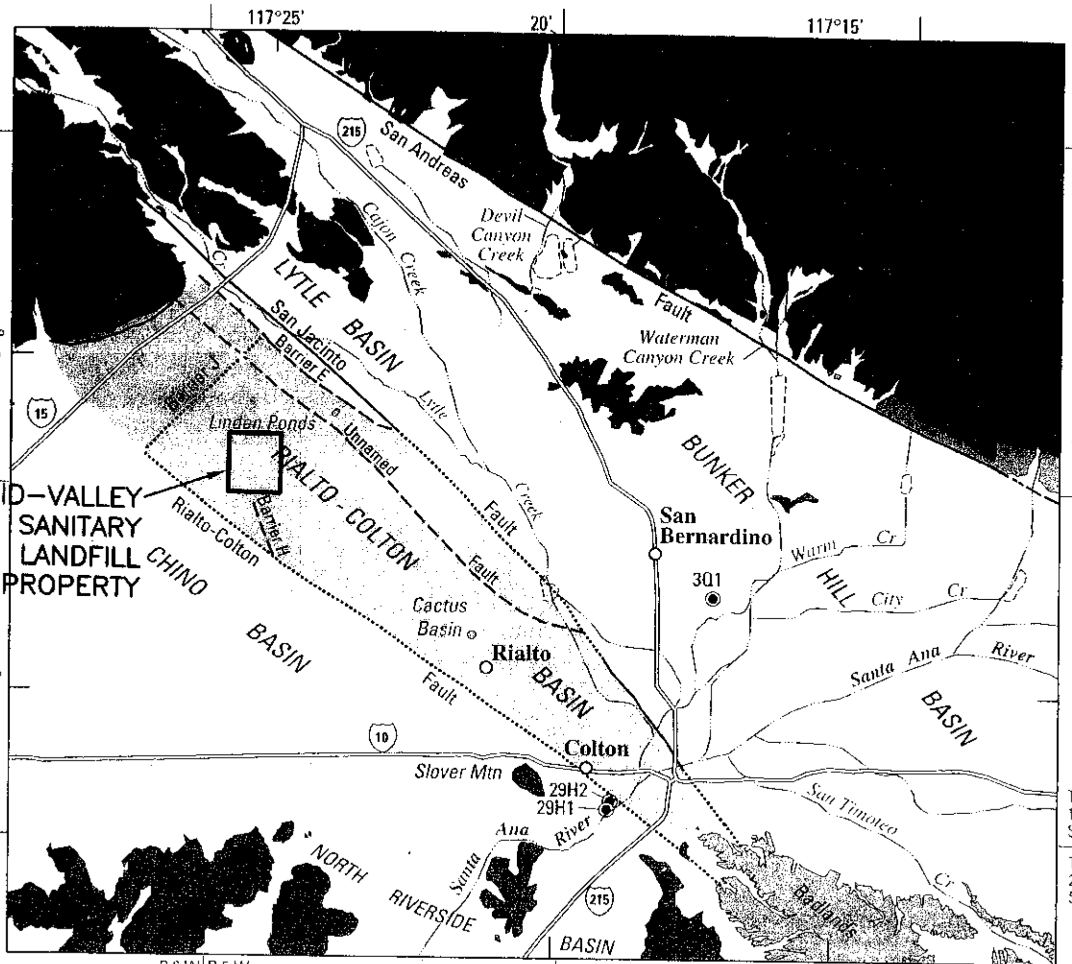


FIGURE 1

PROPOSED WELL LOCATIONS		
SUPPLEMENTAL PERCHLORATE INVESTIGATION FORMER BUNKER AREA RIALTO, CA		
GeoLogic Associates Geologists, Hydrogeologists, and Engineers		
DRAWN BY: VL	DATE: FEBRUARY 2004	JOB NO. 2003-040



Base from U.S. Geological Survey
1:100,000 San Bernardino, 1982

0 5 MILES
0 5 KILOMETERS

EXPLANATION

Unconsolidated deposits – Shaded in Rialto-Colton Basin

Partly consolidated deposits

Consolidated rocks

Fault – Dashed where approximately located, dotted where concealed

Contact

3Q1 **Production well and number** – Used to calculate hydraulic gradient across the Rialto-Colton Basin

FIGURE 2

REGIONAL HYDROGEOLOGIC SETTING
SUPPLEMENTAL PERCHLORATE INVESTIGATION
FORMER BUNKER AREA
RIALTO, CA

GeoLogic Associates
Geologists, Hydrogeologists, and Engineers

DRAWN BY:	DATE:	JOB NO.
VL	FEBRUARY 2004	2003-040

REFERENCE:
USGS WATER-RESOURCES INVESTIGATIONS REPORT 00-4243, BY WOOLFENDEN AND KOCZOT, 2001

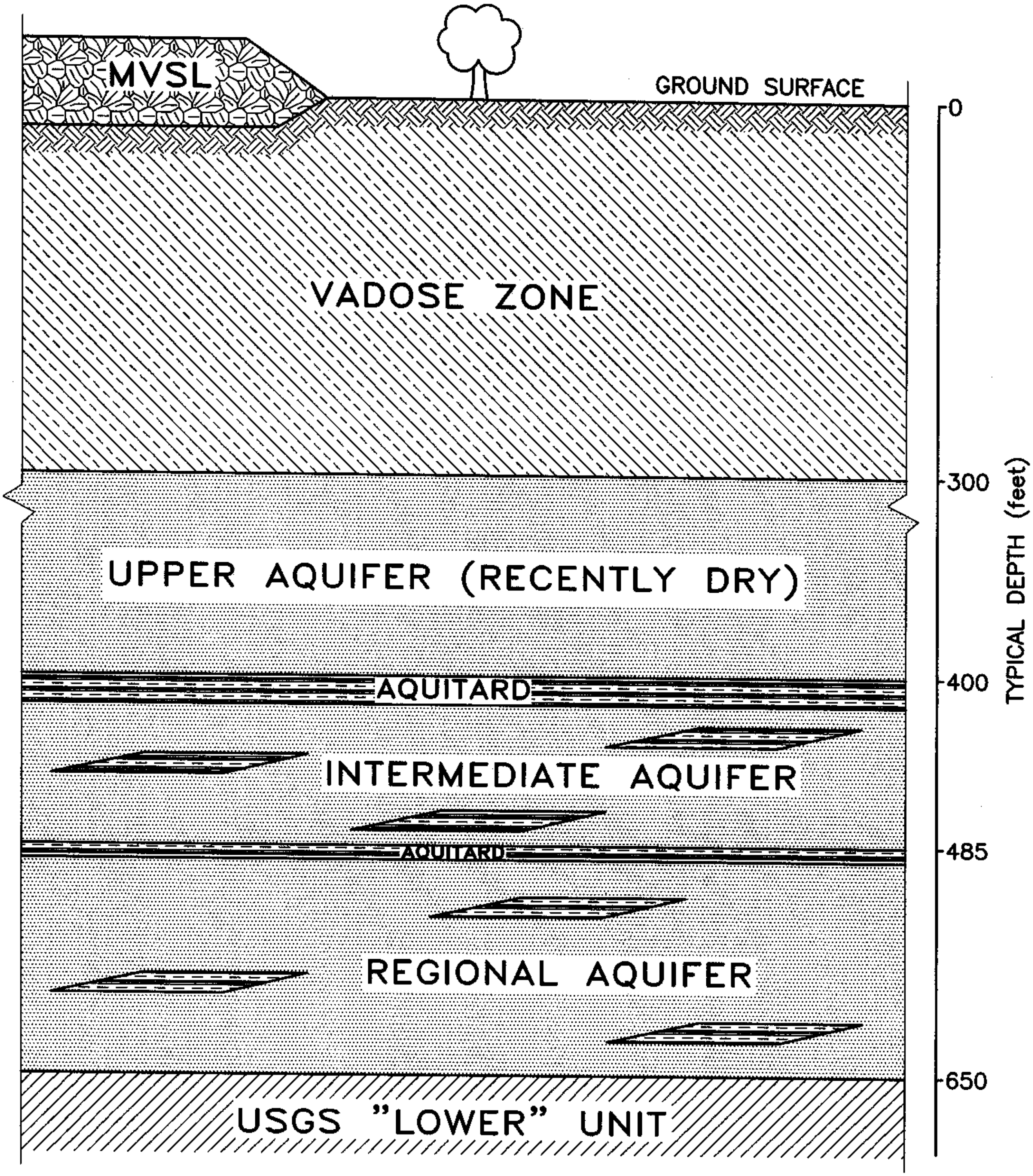


FIGURE 3

LOCAL AQUIFER CONDITIONS

SUPPLEMENTAL PERCHLORATE INVESTIGATION
FORMER BUNKER AREA
RIALTO, CA

GeoLogic Associates
Geologists, Hydrogeologists, and Engineers

DRAWN BY:	DATE:	JOB NO.
VL	FEBRUARY 2004	2003-040

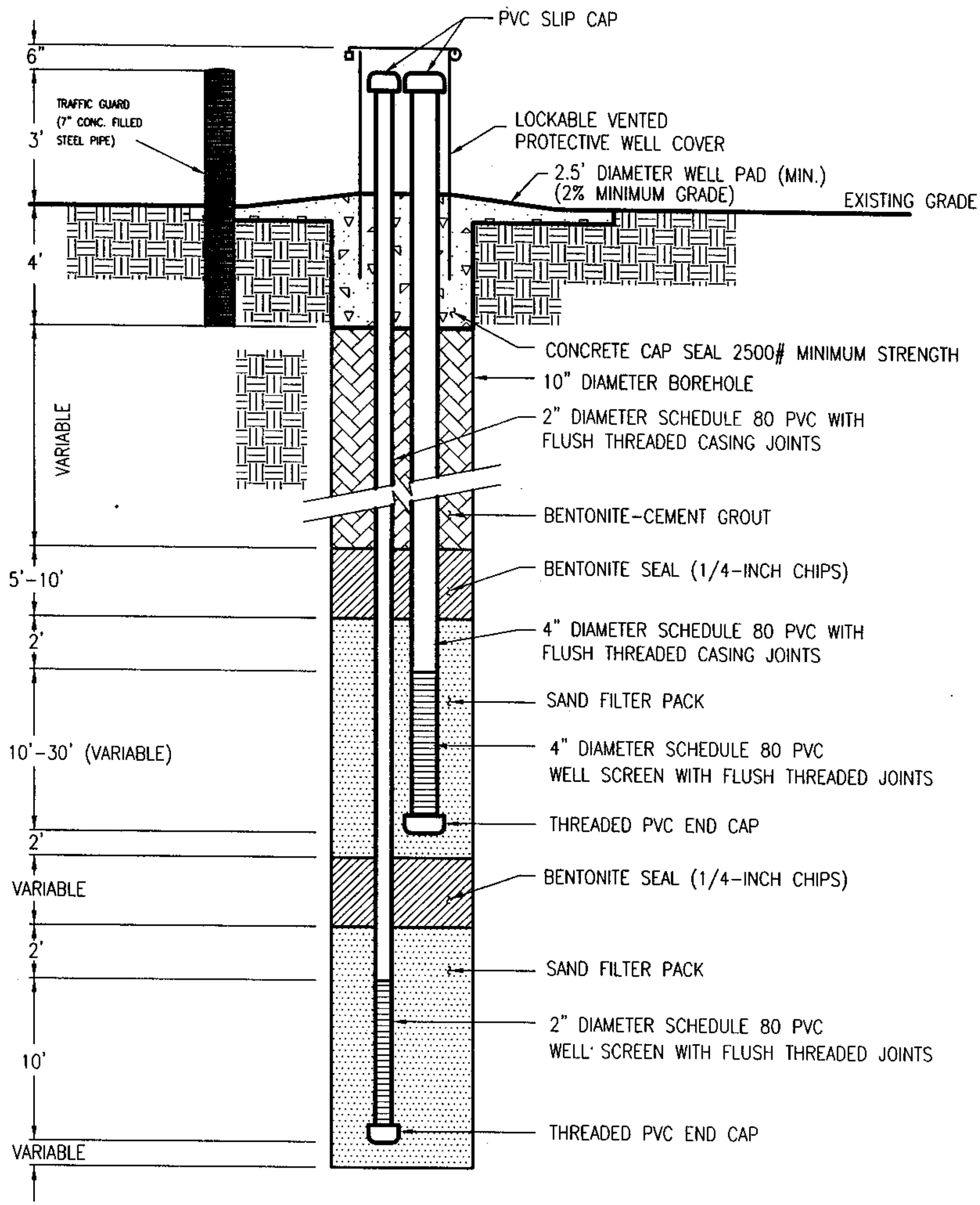


FIGURE 4

TYPICAL WELL/PIEZOMETER CONSTRUCTION DETAIL

SUPPLEMENTAL PERCHLORATE INVESTIGATION
FORMER BUNKER AREA
RIALTO, CA

GeoLogic Associates
Geologists, Hydrogeologists, and Engineers

DRAWN BY:	DATE:	JOB NO.
VL	FEBRUARY 2004	2003-040

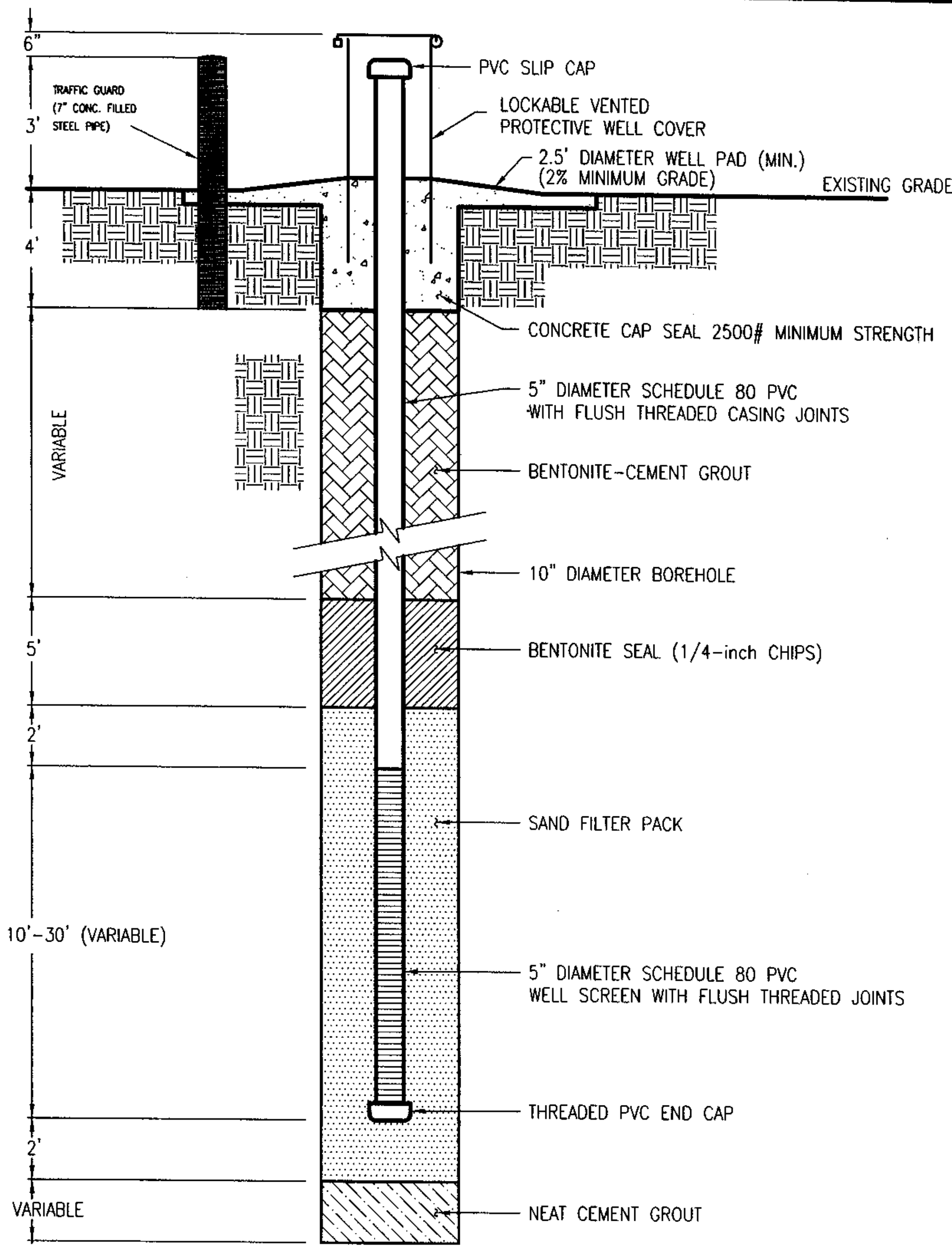


FIGURE 5

TYPICAL 5" MONITORING WELL CONSTRUCTION DETAIL		
SUPPLEMENTAL PERCHLORATE INVESTIGATION FORMER BUNKER AREA RIALTO, CA		
GeoLogic Associates Geologists, Hydrogeologists, and Engineers		
DRAWN BY: VL	DATE: FEBRUARY 2004	JOB NO. 2003-040

GeoLogic Associates
Geologists, Hydrogeologists and Engineers

PROJECT WORKPLAN

SUPPLEMENTAL GROUNDWATER MODELING FOR INVESTIGATION OF PERCHLORATE AND VOLATILE ORGANIC COMPOUNDS IMPACTS TO GROUNDWATER

SAN BERNARDINO COUNTY, CALIFORNIA

IN RESPONSE TO REGIONAL WATER QUALITY BOARD ORDER NO. R8-2003-0013

1.0 INTRODUCTION

1.1 GENERAL

As required by Regional Water Quality Control Board – Santa Ana Region (RWQCB) Order No. R8-2003-013 the County of San Bernardino Solid Waste Management Division (the County) submitted the results of groundwater modeling completed to better characterize the nature and extent of perchlorate and volatile organic compound (VOC) impacts to groundwater adjacent to the former Bunker Area east of the County's Mid-Valley Sanitary Landfill (MVSL) in Rialto, California (Geo-Logic Associates, 2003). Following review of the model, the RWQCB expressed concerns regarding the the suitability of some of the hydrologic parameters that were integrated in the County's model and indicated that transient groundwater flow and contaminant transport conditions needed to be addressed in an updated model (RWQCB letter dated January 15, 2004). This Work Plan identifies supplemental groundwater modeling that the County proposes to perform to respond to the RWQCB letter and better characterize the impacts identified in the area. .

As described herein, the supplemental modeling work proposed by the County will integrate the new hydrostratigraphic, hydrochemical and aquifer testing data that will be generated in the next few months during installation of the supplemental groundwater monitoring wells that the RWQCB has directed the County to install. In addition, it is anticipated that the model may also integrate data that will soon be developed by other potentially responsible parties who are currently, or will shortly be, conducting hydrogeologic studies in the project area.

Specifically, this project will include:

- Coordination with the RWQCB regarding hydraulic parameters to be integrated in the model.

- Integration of new hydrostratigraphic and aquifer testing data derived from the County's proposed supplemental field and laboratory investigation, as well as any data that may become available from other investigations that are currently, or will shortly be, underway in the area.
- Integration of a larger set of historical production well pumping data and historical climate (rainfall) data.
- Development of transient case groundwater flow and contaminant transport simulations.
- Calibration of transient simulations to historical groundwater elevations and contaminant distributions in the northern portion of the Rialto-Colton Basin.
- Preparation of a Supplemental Groundwater Modeling Report.

1.2 BACKGROUND

1.2.1 Perchlorate Impacts to Regional Municipal Production Wells

In 1997 and 1998, the Cities of Rialto and Colton, and West San Bernardino County Water District (now West Valley Water District [WVWD]), collected groundwater samples from their municipal supply wells in the Rialto-Colton Groundwater Basin. Perchlorate was measured at concentrations above 18 µg/L in five of the wells and a perchlorate concentration of over 700µg/L was measured in samples from WVWD No. 22, the well located closest to the former Rialto Ammunition Backup Storage Point (RABSP).

Owing to its age and impacted condition, WVWD subsequently converted Well No. 22 into a 2-stage monitoring well by constructing two separate sections of polyvinyl chloride (PVC) well screen separated by sealed solid PVC sections. This allowed for evaluation of perchlorate concentrations at two depths within the original well bore and yielded detection of perchlorate at concentrations as high as 820 µg/L.

1.2.2 Perchlorate Monitoring at MVSL Monitoring Wells

Monitoring for perchlorate in the vicinity of the MVSL was first conducted at all area monitoring wells in October 1997. At that time, perchlorate was detected at only one well (F-6 at the southeastern corner of Unit 2; Figure 1) where a concentration of 4.2 µg/L (just above the laboratory's practical quantitation limit [PQL]) was measured. During the 11 quarterly monitoring events between October 1997 and July 2000, perchlorate was routinely tested for but detected at well F-6 just two more times. These detections were reported at only trace-level concentrations (i.e., below the laboratory's PQL). In July 2000 the perchlorate concentration in the sample from well F-6 was measured at 10 µg/L (significantly above the laboratory PQL) and by January 2001 it had risen to 250 µg/L. Since January 2001, perchlorate concentrations in samples from well F-6 have fluctuated between 56 and 300 µg/L.

Following the initial increase in perchlorate concentrations at well F-6, samples from well F-3 were again tested for perchlorate. Though no perchlorate was detected in the F-3 sample collected in January 2001, by April 2001 perchlorate was detected in well F-3 at 18 µg/L. Perchlorate concentrations then rose to a high of 48 µg/L in July 2001, after which it declined to a low of 17 µg/L just before the well went dry in January 2002.

Perchlorate has not been detected in any other County monitoring wells.

1.2.3 Recent Perchlorate Investigation

Following identification of perchlorate in monitoring well samples, the RWQCB issued Cleanup and Abatement Order No. R8-2003-0013 on January 17, 2003. In response to that Order, the County prepared Work Plan (March 2003) to investigate perchlorate impacts to soils and groundwater near the former Bunker Area, east of the MVSL. The groundwater components of the Work Plan were completed in October 2003 and a project report that was subsequently submitted to the RWQCB (GeoLogic Associates, October 2003). Earlier investigation included:

- Literature and aerial photograph review to identify potential sources of perchlorate impacts in the area.
- Excavation of 17 shallow exploratory soils borings within stockpiled bunker debris and associated soils at the Robertson's Ready-Mix aggregate processing plant located east of the former Bunker Area.
- Excavation of 5 deep exploratory soil borings within an accessible portion of the former Bunker Area.
- Installation of 57 temporary wells and 13 permanent groundwater monitoring wells upgradient, cross-gradient, and downgradient of the former Bunker Area.
- Development of a three-dimensional numerical groundwater model of the project area to simulate groundwater flow and contaminant transport conditions near the site and to evaluate alternative responses to groundwater impacts in the area.

Based on the results of the field and laboratory investigation, and as supported by the results of the numerical groundwater model that was prepared for the project, GeoLogic Associates concluded that:

- The detection of only trace concentrations of perchlorate and the absence of explosives in samples collected from bunker debris suggests that soils stockpiled at the Robertson's Ready-Mix plant do not pose a significant threat to water quality in their current condition.

- While the soil samples that were collected from beneath the former Bunker Area also failed to identify significant concentrations of perchlorate, the historical use of the property and detection of elevated concentrations of perchlorate in groundwater beneath the former Bunker Area suggests that soils in this area could contain elevated concentrations of perchlorate.

- Groundwater downgradient of the former Bunker Area has been impacted by elevated concentrations of perchlorate and a variety of VOCs. Perchlorate concentrations in temporary wells were as high as 820 μg/L at well F-6A, 710 μg/L at well N-5, 350 μg/L at well N-3, and 267 μg/L at well N-8 (Figure 1). Within permanent wells, perchlorate was measured at concentrations as high as 1000 μg/L at well N-3 (currently only 100 μg/L), 530 μg/L at well N-5, and 310 μg/L at well N-8. The most commonly detected VOC was trichloroethene, which was found at concentrations that commonly exceeded its maximum contaminant level (i.e., > 5 μg/L).

- The spatial distribution of perchlorate impacts suggests that the 1999 perchlorate release to groundwater from the former Bunker Area is relatively restricted and does not extend more than about 4000 feet to the southeast (downgradient). Perchlorate-related impacts that have been identified in municipal production wells in the region do not appear to be associated with the Bunker Area release.

1.2.4 Additional RWQCB Requirements

Following submittal of the investigation results, the RWQCB presented comments regarding the report to the County (letter January 15, 2004). The most significant issues raised by the RWQCB with regard to the soil and groundwater characterization included:

- The RWQCB agreed that no information exists to suggest that the MVSL itself is responsible for perchlorate impacts to groundwater in the area.

- Owing to the relative absence of perchlorate in soil samples obtained from bunker area debris stockpiled at the Robertson's Ready-Mix plant, this phase of the investigation is considered complete.

- Recognizing the detection of low concentrations of perchlorate and VOCs in soil samples collected within the eastern portion of the former Bunker Area, and considering the detection of elevated perchlorate concentrations in select groundwater samples obtained in this area, the County may be required to conduct further soil and groundwater investigations. These studies may occur as part of any "closure" work required by the California Department of Toxic Substance Control.

- The RWQCB ordered that a Work Plan be submitted for further characterization of impacted groundwater conditions. The RWQCB Order requires that the Work Plan include provisions for installation of 5 additional groundwater monitoring wells to better delineate the limit of perchlorate impacts.

- Noting the disparity between hydraulic parameters included in a U.S. Geological Survey numerical model of the Rialto-Colton Basin and the values included in GeoLogic Associates' numerical model of the area downgradient of the former Bunker Area, the RWQCB concluded that GeoLogic Associate's model requires further verification to determine the downgradient extent of the contaminant plume.

- In order to develop a groundwater model for the perchlorate and VOC plumes in the immediate vicinity of the former Bunker Area, and possibly to extend the model to include other impacted wells within the Rialto-Colton Basin, the RWQCB also directed the County to submit a second Work Plan for development of a "conceptual groundwater model".

This Work Plan addresses the RWQCB's request for additional groundwater modeling. The RWQCB's request for development of a work plan for additional groundwater monitoring wells is being submitted as a separate submittal.

1.3 GEOLOGIC SETTING

The MVSL is located near the northern end of the Peninsular Ranges Geomorphic Province near its junction with the Transverse Ranges Geomorphic Province. This area of southwestern San Bernardino County is underlain by several fault-bound structural blocks, including the down-dropped San Bernardino Valley Block located between the San Andreas and San Jacinto Faults; and the down-dropped Perris Block between the Elsinore Fault to the west, the Cucamonga Fault to the north and the San Jacinto Fault to the east (Fife et al., 1976). The MVSL is located in the northeastern portion of the Perris Block.

The landfill site is underlain by a considerable thickness of Quaternary alluvium overlying the Mesozoic basement complex. The maximum thickness of alluvium in the area is estimated to be greater than 900 feet near the Kaiser Steel Plant, approximately 6 miles southwest of the site (Fife et al., 1976). Unconsolidated Quaternary gravels, sands, silts, and clays associated with alluvial fan deposits (Qf) are exposed throughout the area and relatively recent channel deposits are present in all of the local unimproved drainages. Water well data in the vicinity suggests that some continental Tertiary deposits may be present between the Quaternary and older underlying Mesozoic units, though no local exposures of these materials have been identified. The basement complex underlying the alluvium and exposed in the San Gabriel Mountains north of the site consists of granitic and metamorphic rocks.

The site is located within a tectonically active region and several active faults exist within 30 miles of the property. These include faults of the San Andreas, San Jacinto, Cucamonga, Glen Helen, and Whittier-Elsinore Fault zones. The nearest active faults in the area are the San Jacinto Fault, located 2.6 miles to the northeast of the site and the Cucamonga Fault Zone located about 2.3 miles to the northwest. No known active or potentially active faults have been located on the property.

1.4 HYDROGEOLOGIC SETTING

1.4.1 Regional Setting

The MVSL is located within the northwest portion of the Rialto-Colton groundwater basin (Dutcher and Garrett, 1963). Groundwater flow in the basin is controlled by several barriers and faults that have been identified; some of which delineate the lateral boundaries of the basin. The Rialto-Colton Basin extends from Barrier J on the northwest to the Santa Ana River on the southeast (Figure 2). On the northeast it is bounded by the San Jacinto Fault, which separates the basin from the Lytle and Bunker Hill Basins. On the southwest it is separated from the Chino Basin by the Rialto-Colton Barrier and by Barrier H. Dutcher and Garrett (1963) have presented evidence to indicate that inflow to the northwest portion of the basin is almost exclusively by leakage through Barrier J, with only a minor contribution from precipitation and infiltration. Recent work by the U.S. Geological Survey (Woolfenden, 1998) indicates that significant underflow may also occur across the northern portions of the San Jacinto Fault where it is coincident with Lytle Creek. South of this area, underflow across the San Jacinto Fault (Barrier E) is limited. On the west side of the basin, the northern portions of the Rialto-Colton Barrier impedes groundwater flow.

Although some investigators of the basin doubt that Barrier H exists (Fox and Roberts, 1995), Dutcher and Garrett (1963) identified Barrier H as a sub-parallel feature of the Rialto-Colton Fault. Fontana Union Water Company (FUWC) wells F-10A and F-10B are located near the junction of the Rialto-Colton Fault, Barrier H, and an unnamed barrier first identified by the California Department of Water Resources that extends northwest toward the MVSL (CDMG, 1970).

Groundwater in the Rialto-Colton Basin occurs within alluvial sediments at depths ranging from more than 400 feet below ground surface (bgs) northeast of the site to less than 100 feet bgs closer to the mountain front. Near the Santa Ana River groundwater is even shallower (Figure 2). Water well data suggests that groundwater in the northern and central portions of the Rialto-Colton Basin flows to the south and southeast under an average gradient of about 0.02 to 0.04 ft./ft (Woolfenden and Kadhim, 1997).

U.S. Geological Survey studies of the Rialto-Colton Basin identified three hydrologic units (Woolfenden and Kadhim, 1997) in the project area. The upper unit is saturated only in areas adjacent to active watercourses such as Lytle Creek and the Santa Ana River. Near the MVSL, the middle unit is saturated. At depths below about 600 to 700 feet, the lower unit yields smaller volumes of water.

1.4.2 Local Conditions

Groundwater investigations completed near the MVSL (GLA, 1997a, 1997b, 2003) have identified three laterally-continuous aquifers within what Woolfenden and Kadhim (1997) first identified as the Rialto-Colton Basin's middle hydrologic unit. These include an upper unconfined aquifer (hereafter the Upper Aquifer) that occurs at depths of about 245 to 340 feet below ground surface, an intermediate partially confined aquifer (hereafter, Intermediate Aquifer), and a deep regional confined aquifer (hereafter, Regional Aquifer) that provides much of the groundwater that is pumped in the area by municipal supply wells. The three aquifers are separated by laterally continuous, relatively low-permeability aquitards that generally range in thickness from only a few feet to over 30 feet (Figure 3).

Groundwater in each of the aquifers occurs in sandy gravels, gravelly sands, and sands that typically have excellent water-bearing and water-yielding properties. Drilling and well installation data suggest that the three aquifers are laterally continuous with a downward hydraulic gradient between the individual units. While the Upper Aquifer had a saturated thickness of about 15 to 35 feet between 1996-1998 (GLA, 1997b, 1998), regional drought conditions have resulted in dewatering of much of the unit today. As a result, the uppermost groundwater that was consistently encountered in the recent investigation was identified in the Intermediate Aquifer.

In the project area, the Intermediate Aquifer is about 40 to 140 feet thick and its potentiometric surface typically extends above the top of the overlying aquitard. As discussed below, the Intermediate Aquifer actually consists of a number of smaller water-bearing units that are separated by relatively thin (e.g., < 5 feet thick) aquitards with a downward hydraulic gradient between the subunits. In the upper portion of the Intermediate Aquifer, the downward hydraulic gradient is typically less than a few feet while, at depth, the downward gradient was measured to be as much as 65 feet. A significantly thicker aquitard (the Regional Aquitard) separates the Intermediate Aquifer from the Regional Aquifer and a substantial downward hydraulic gradient exists between these two units. This hydraulic gradient is almost 100 feet across the aquitard, and as much as 170 feet between the uppermost groundwater unit in the Intermediate Aquifer and the Regional Aquifer.

Though the full thickness of the Regional Aquifer was not penetrated by the project wells, data presented by Woolfenden and Kadhim (1997) indicate that in this area of the Rialto-Colton Basin the Regional Aquifer may extend 150 feet beyond the base of the Regional Aquitard. Below this depth, the "lower groundwater unit" and consolidated Tertiary marine sedimentary deposits are expected to yield significantly smaller volumes of groundwater.

Groundwater elevations are measured routinely in monitoring wells near the MVSL (GLA, 1992-2003). These data indicate that groundwater elevations at the site have dropped as much as 58 feet within the past 4 years, though groundwater equipotential plans developed from MVSL monitoring data consistently indicate a southeasterly groundwater flow direction in the local Upper, Intermediate, and Regional Aquifers. Measured gradients are generally consistent with the regional gradients identified by the U.S. Geological Survey (Woolfenden and Kadhim, 1997).

The results of aquifer tests completed for the Phase I VOC EMP (GLA, May 1997a) and the results of tests completed for the recently completed perchlorate investigation (GLA, 2003) indicate that the hydraulic conductivity of the Upper and Intermediate Aquifer materials in the project area are similar and range from about 10 to 60 feet/day. Literature review suggests that the porosity in both aquifers should be approximately 20 to 35 percent (Driscoll, 1986). Based on these values and the average hydraulic gradient measured in the area (about 0.018 ft/ft), the groundwater velocity in the project area is estimated to be approximately 1 to 5 feet per day.

2.0 PROPOSED SCOPE OF WORK

2.1 GENERAL

This Work Plan identifies procedures and protocols that will be followed to update the County's existing numerical groundwater model of the project area. Individual elements of the project are discussed in the following sections.

2.2 COORDINATION WITH RWQCB

In addition to reviewing data as it becomes available from the new groundwater monitoring wells, it is expected that the County will also work with the RWQCB to review and refine past modeling efforts. It is expected that a broader understanding of the existing modeling work will promote a concerted focus on techniques and parameters that may optimize the model and ultimately support identification of appropriate corrective action measures.

Of note, and as addressed in the cover to letter to this Work Plan, the RWQCB has expressed reservations regarding the contrast that exists between some of hydraulic parameters that were integrated in the U.S. Geological Survey's (USGS's) model of the Rialto-Colton Basin (Wulfenden and Kadhim, 1997) and the values that were selected for use in the County's existing model (Geo-Logic Associates, 2003). The differences between the two model input data sets appear to be largely associated with the different scales of the two models. Since the USGS model considered the entire Rialto-Colton Basin, it necessarily involved a more general evaluation of regional hydrogeologic conditions. In contrast, the County's model focused on groundwater conditions near the former Bunker Area and integrated hydrostratigraphic and aquifer pumping test data that were not considered in the USGS model. Since the County's model incorporates greater detail regarding local hydrostratigraphy, it is better suited to contaminant transport analyses within the project area. Again, it is expected that a better understanding of the unique character of the two model sets will not only facilitate model refinement but will help clarify the apparent contrast in the two models.

As indicated in the RWQCB's letter and attachments of January 15, 2004, interested parties differ significantly with respect to what constitutes appropriate hydraulic parameter input for a groundwater model of the area. Recognizing these differences and considering that these parties may have different project objectives, the County hopes to work directly with the RWQCB to identify appropriate input parameters to refine the County's groundwater model. To that end, the County will maintain routine communications with the RWQCB to identify and substantiate the parameters that are included in the model.

2.3 INTEGRATION OF NEW HYDROGEOLOGIC DATA

Construction of the County's new groundwater monitoring wells, and construction of new monitoring wells by other parties northeast of the former Bunker Area will generate significant data regarding aquifer and contaminant conditions in the project area. It is assumed that the RWQCB will make the new data from other parties available to the County for use in the model. Specifically, these additional investigative efforts are expected to provide information regarding:

- Hydrostratigraphy and distribution and relative effectiveness of aquitards. [The County's existing model indicates that the geometry of the aquitard that separates the Intermediate and Regional aquifers is quite significant with respect to groundwater flow and contaminant transport trajectories.]
- Concentrations and mass loads of contaminants.
- Aquifer hydraulic properties.

2.4 INTEGRATION OF ADDITONAL HISTORICAL DATA

While available information regarding the locations, depths, and pumping rates of municipal pumping wells in the area was used wherever possible during development of the County's model, completion of the new transient case simulations (i.e., model simulations that reflect changing, rather than steady-state, conditions) requires that groundwater purveyors in the region make more data available regarding historical well construction and operations. Specifically, it is expected that the RWQCB will assist the County in obtaining drillers logs, borehole geophysical logs, monthly summaries of groundwater production rates, and contaminant analytical data so that this data can be effectively integrated in the model. In addition to the well information, published data regarding historical climate (precipitation) data will be obtained to support the project's transient analyses.

2.5 TRANSIENT ANALYSES

The results of the investigative and modeling work completed by the County suggest that changing groundwater elevations through time could be an important influence on groundwater and contaminant flow. While the calibration results for the County's existing model have been relatively good for the two base, steady-state conditions that were considered, additional transient analyses will be completed to further evaluate past and potential future contaminant migration. In completing these analyses, data regarding past municipal well pumping rates and groundwater elevations will be critical, as will calibration to both historic and current groundwater elevations and contaminant concentrations

2.6 SUPPLEMENTAL GROUNDWATER MODELING REPORT

Following refinement of the model and completion of the transient analyses, the existing groundwater model report will be updated for submittal to the RWQCB. The report will describe the methods and procedures employed in the model, identify and substantiate the hydraulic parameters integrated in the model, detail the updated calibration results (steady-state and transient; elevations and concentrations), and present the results of steady-state and transient flow simulations.

3.0 PROJECT SCHEDULE

The anticipated schedule for completing the work described above is presented below. Although every effort will be made to keep the project schedule "on track", it is possible that data availability (e.g., well construction delays) could delay the work.

The following milestones in the proposed schedule are critical to the prompt completion of the project work:

- <u>Meet RWQCB to Review Existing Model</u> – March 26, 2004
- <u>Integration of Historical Production Well Data</u> - June 28, 2004
- <u>Integration of New Monitoring Well Data</u> - July 16, 2004
- <u>Integration of Aquifer Testing Data</u> – July 30,2004
- <u>Evaluation of RWQCB Suggestions to Refine Existing Model</u> – August 13, 2004
- <u>Calibration of Transient Model</u> – November 15, 2004
- <u>Completion of Transient (future case) Simulations</u> – December 15, 2004.
- <u>Updated Groundwater Model Report</u> – January 30, 2005.

4.0 CLOSURE

This Work Plan is based on the limited data described above and referenced herein. GeoLogic Associates should be notified of any conditions that differ from those described herein since this may require a re-evaluation of the work-plan elements presented herein. This Work Plan has not been prepared for use by other parties and projects other than those named or described above. It may not contain sufficient information for other parties or other purposes.

GeoLogic Associates

Gary L. Lass, C.E.G., C.H.G
President

Attachments: Figures 1 through 3

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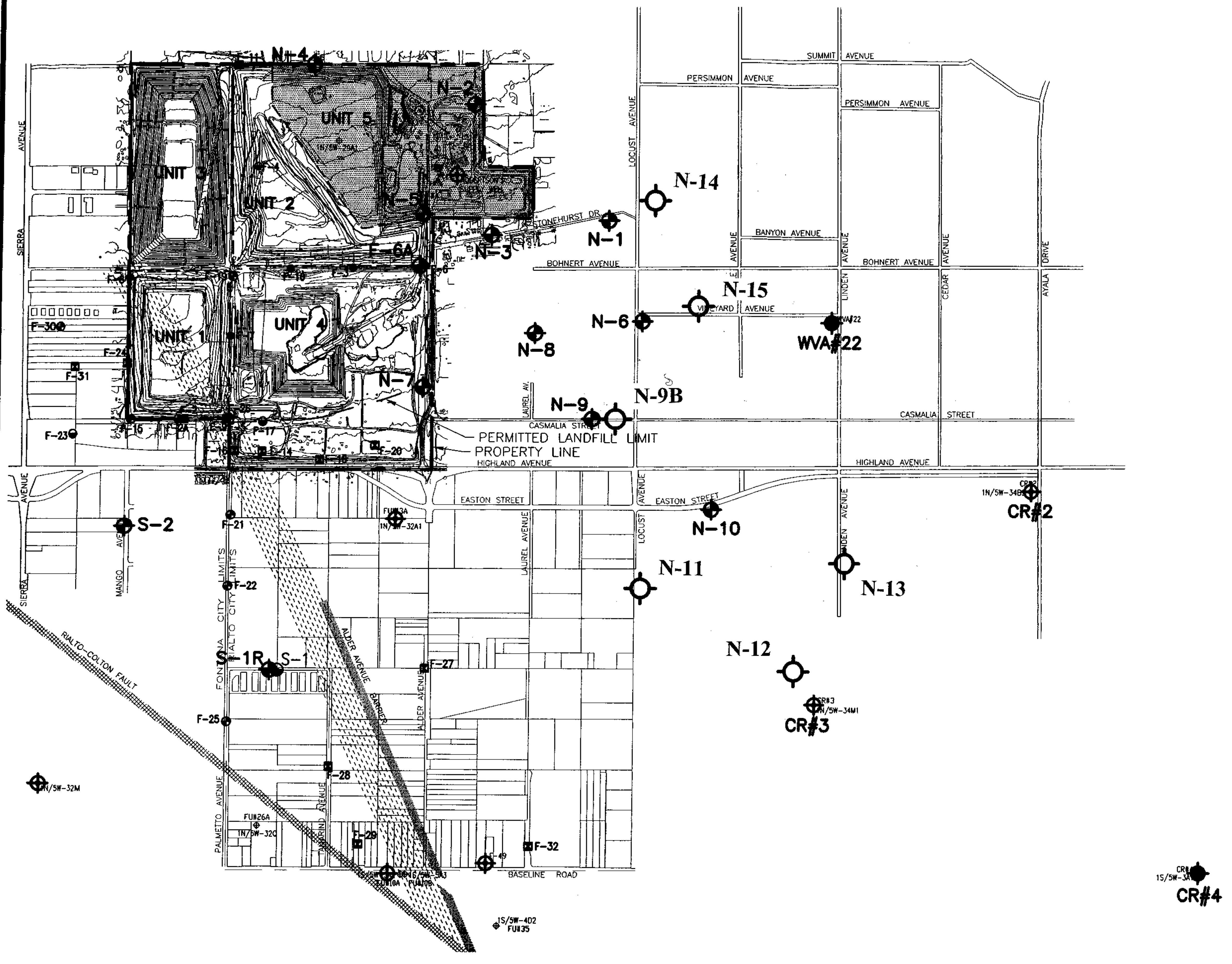
FIGURES



EXPLANATION:

- PROPOSED WELL LOCATION
- PERCHLORATE INVESTIGATION WELL
- PRODUCTION WELL WITH HISTORIC PERCHLORATE DETECTION
- PRODUCTION WELL WITH NON-DETECTABLE PERCHLORATE
- MULTIPLE AQUIFER MONITORING WELL LOCATION
- UNCONFINED AQUIFER MONITORING WELL LOCATION
- INTERMEDIATE CONFINED AQUIFER MONITORING WELL LOCATION
- ABANDONED MONITORING WELL LOCATION
- 1N/5W-32A1 FU#13A MUNICIPAL WATER WELL LOCATION WITH OWNERSHIP AND OWNER'S ID (WHEN AVAILABLE)
- POSTULATED LOCATION OF ALDER AVENUE BARRIER
- FORMER BUNKER AREA OF COUNTY PROPERTY

N

GRAPHIC SCALE

650 0 325 650 1300

(in feet)

1 inch = 1300 ft.

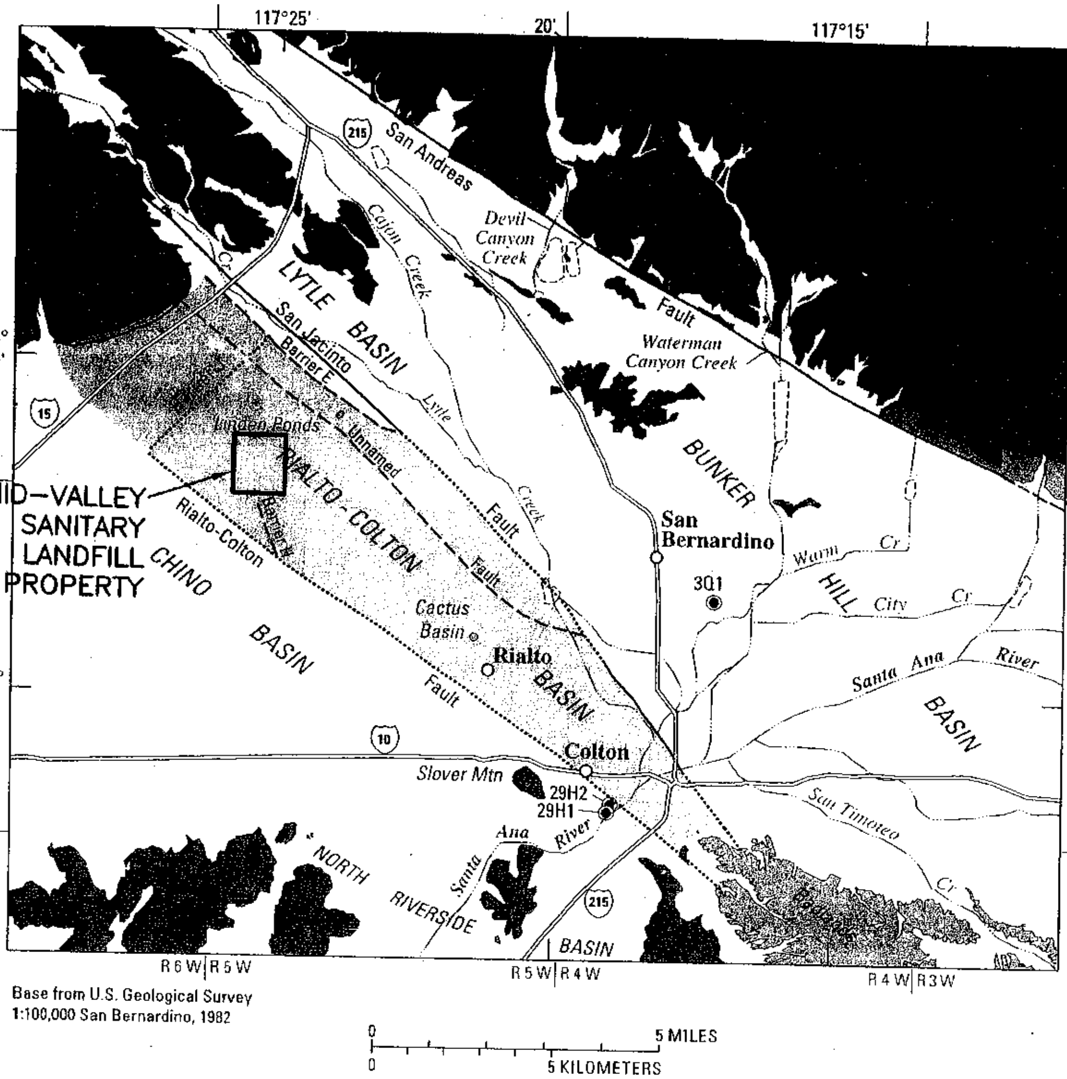
FIGURE 1

PROPOSED WELL LOCATIONS

SUPPLEMENTAL PERCHLORATE INVESTIGATION
FORMER BUNKER AREA
RIALTO, CA

GeoLogic Associates
Geologists, Hydrogeologists, and Engineers

DRAWN BY:	DATE:	JOB NO.
VL	FEBRUARY 2004	2003-040



EXPLANATION

Unconsolidated deposits – Shaded in Rialto-Colton Basin

Partly consolidated deposits

Consolidated rocks

Fault – Dashed where approximately located, dotted where concealed

Contact

3Q1 **Production well and number** – Used to calculate hydraulic gradient across the Rialto-Colton Basin

FIGURE 2

REGIONAL HYDROGEOLOGIC SETTING

SUPPLEMENTAL PERCHLORATE INVESTIGATION
FORMER BUNKER AREA
RIALTO, CA

GeoLogic Associates
Geologists, Hydrogeologists, and Engineers

DRAWN BY:	DATE:	JOB NO.
VL	FEBRUARY 2004	2003-040

REFERENCE:
USGS WATER-RESOURCES INVESTIGATIONS REPORT 00-4243, BY WOOLFENDEN AND KOCZOT, 2001

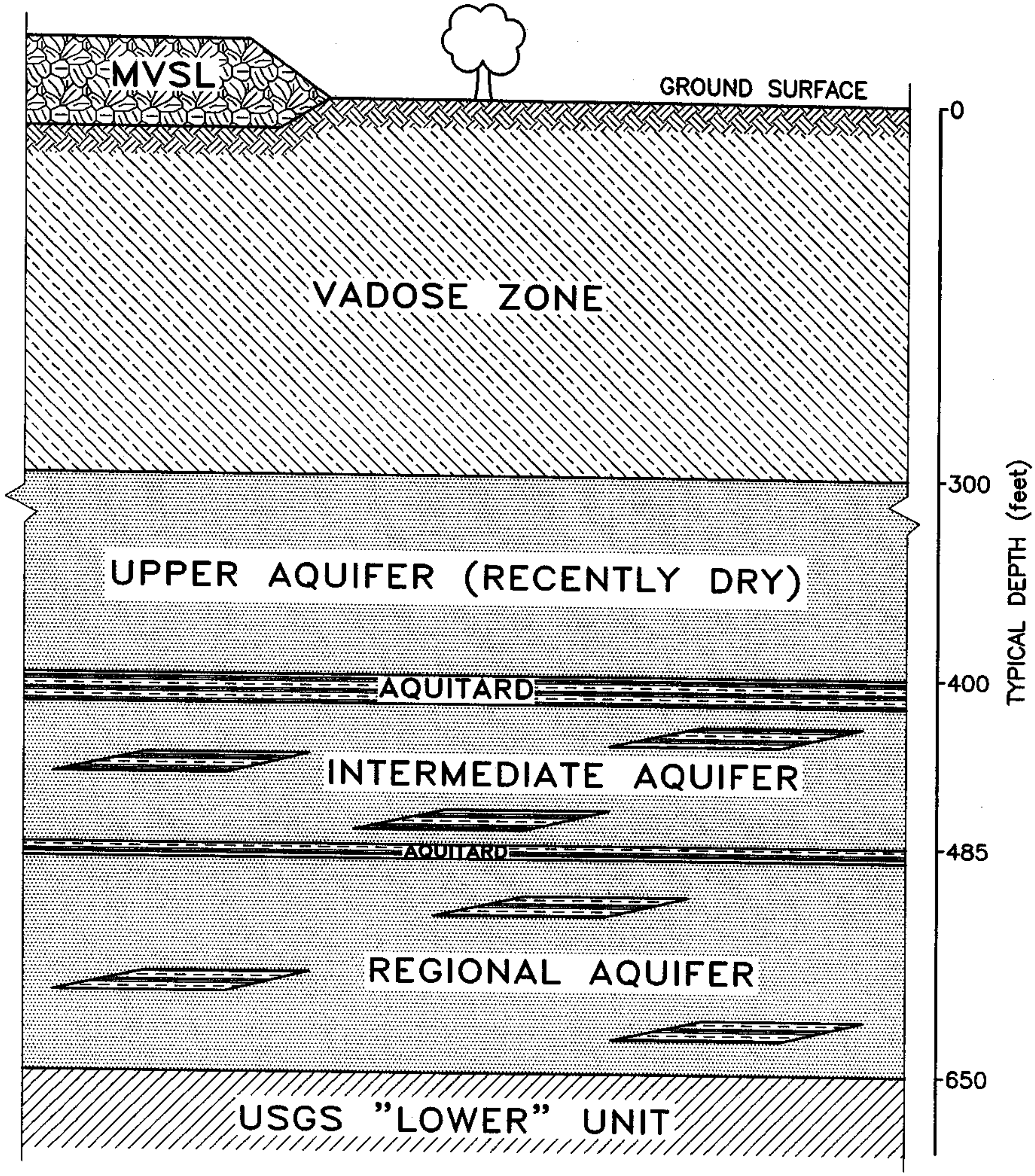


FIGURE 3

LOCAL AQUIFER CONDITIONS

SUPPLEMENTAL PERCHLORATE INVESTIGATION
FORMER BUNKER AREA
RIALTO, CA

GeoLogic Associates
Geologists, Hydrogeologists, and Engineers

DRAWN BY:	DATE:	JOB NO.
VL	FEBRUARY 2004	2003-040

DEPARTMENT OF PUBLIC WORKS

FLOOD CONTROL • GIMS • REGIONAL PARKS • SOLID WASTE • SURVEYOR • TRANSPORTATION

COUNTY OF SAN BERNARDINO
ECONOMIC DEVELOPMENT
AND PUBLIC SERVICES GROUP

SOLID WASTE MANAGEMENT DIVISION
222 West Hospitality Lane, Second Floor • San Bernardino, CA 92415-0017 • (909) 386-8701
Administration/Engineering/Solid Waste Programs Fax (909) 386-8900
Fiscal Section/Operations Fax (909) 386-8786

KEN A. MILLER
Director of Public Works

PETER H. WULFMAN
Solid Waste Division Manager

February 26, 2004

Mr. Gerard J. Thibeault, Executive Officer
California Regional Water Quality Control Board
Santa Ana Region
3737 Main Street, Suite 500
Riverside, California 92501-3339

RE: SUBMITTAL OF WORK PLAN FOR PREPARATION OF "REMEDIAL ACTION PLAN" AND "ENGINEERING EVALUATION OF MITIGATION ALTERNATIVES," IN RESPONSE TO RWQCB CLEANUP AND ABATEMENT ORDER R8-2003-0013, FORMER BUNKER AREA, RIALTO, CALIFORNIA

Dear Mr. Thibeault:

Following your request, and in accordance with the Regional Quality Control Board Cleanup and Abatement Order No. R8-2003-013, the County of San Bernardino Solid Waste Management Division (County) has prepared the enclosed Work Plan for preparation of a Remedial Action Plan (RAP) to address perchlorate and volatile organic compound (VOC) impacts to soil and groundwater near the former Bunker Area property in Rialto, California. This Work Plan supplements the two Work Plans that were submitted to the RWQCB on February 17, 2004 for installation of additional groundwater monitoring wells and development of an enhanced groundwater model of the project area.

As indicated in the RAP Work Plan, the first "deliverable" that the County is to submit to the RWQCB is an interim Engineering Evaluation of Mitigation Alternatives (EE) that are available to address groundwater impacts downgradient of the former Bunker Area. As you will note, the interim EE report has already been prepared by the County's consultant, GeoLogic Associates, and is also enclosed herein. Once installation of the 6 new groundwater monitoring wells that are planned has been completed, and following completion of the additional groundwater modeling work that will soon be underway, the County will update the EE report to address the results of these studies. The updated EE report will then be combined with the soils mitigation Bunker Area "Closure Plan" report that will be prepared in cooperation with the RWQCB and the Department of Toxic Substance Control (DTSC) to produce the RAP document.

The County of San Bernardino looks forward to working with the RWQCB during completion of these studies. If you have any questions or concerns, please contact me at your earliest convenience at (909) 386-8703.

Sincerely,

Arthur L. Rivera

FOR Peter H. Wulfman, P. E.
Division Manager

PHW: js

Enclosures as noted

cc: Arthur L. Rivera, SWMD
Robert Jocks, Deputy County Counsel
Joel S. Moskowitz, MBW&B

PROJECT WORK PLAN

PREPARATION OF CONCEPTUAL REMEDIAL ACTION PLAN

FOR INVESTIGATION OF PERCHLORATE AND VOLATILE ORGANIC COMPOUND IMPACTS TO GROUNDWATER SAN BERNARDINO COUNTY, CALIFORNIA

PREPARED IN RESPONSE TO REGIONAL WATER QUALITY BOARD ORDER NO. R8-2003-0013

1.0 INTRODUCTION

1.1 GENERAL

As directed by the Regional Water Quality Control Board – Santa Ana Region (RWQCB; January 15, 2004), this Work Plan identifies steps that the County of San Bernardino Solid Waste Management Division (County) will take to develop a conceptual remedial action plan to mitigate perchlorate and volatile organic compound (VOC) impacts to groundwater adjacent to the former Bunker Area east of the County's property adjacent to the Mid-Valley Sanitary Landfill (MVSL) in Rialto, California. This Work Plan supplements two other Work Plans that the County recently submitted to the RWQCB to (1) install new groundwater monitoring wells and perform aquifer pumping tests (GeoLogic Associates [GLA] 2004a), and (2) to enhance the County's groundwater model of the project area (GLA, 2004b).

As described herein, the conceptual Remedial Action Plan (RAP) will address both source control (i.e., the potentially impacted soils in the former Bunker Area) and plume containment. Specifically, project work will include:

- Preparation of a "Closure Plan" that identifies measures that will be taken to investigate, delineate, and treat impacted soils in the former Bunker Area.
- Development of an Engineering Evaluation of mitigation alternatives that may be available to contain and treat impacted groundwater and which includes an assessment of the technical advantages and cost/benefits and limitations of differing remedial approaches.
- Submittal of the Closure Plan and Engineering Evaluation in the form of an integrated RAP identifying all the steps that the County will take to address perchlorate and VOC impacts to soils and groundwater in the project area.

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1.2 BACKGROUND

1.2.1 Perchlorate Impacts to Regional Municipal Production Wells

In 1997 and 1998, the Cities of Rialto and Colton, and West San Bernardino County Water District (now West Valley Water District [WVWD]), collected groundwater samples from their municipal supply wells in the Rialto-Colton Groundwater Basin. Perchlorate was measured at concentrations above 18 μg/L in five of the wells and a perchlorate concentration of over 700μg/L was measured in samples from WVWD No. 22, the well located closest to the former Rialto Ammunition Backup Storage Point (RABSP).

Owing to its age and impacted condition, WVWD subsequently converted Well No. 22 into a 2-stage monitoring well by constructing two separate sections of polyvinyl chloride (PVC) well screen separated by sealed solid PVC sections. This allowed for evaluation of perchlorate concentrations at two depths within the original well bore and yielded detection of perchlorate at concentrations as high as 820 μg/L.

1.2.2 Perchlorate Monitoring at MVSL Monitoring Wells

Monitoring for perchlorate in the vicinity of the MVSL was first conducted at all area monitoring wells in October 1997. At that time, perchlorate was detected at only one well (F-6 at the southeastern corner of Unit 2; Figure 1) where a concentration of 4.2 μg/L (just above the laboratory's practical quantitation limit [PQL]) was measured. During the 11 quarterly monitoring events between October 1997 and July 2000, perchlorate was routinely tested for but detected at well F-6 just two more times. These detections were reported at only trace-level concentrations (i.e., below the laboratory's PQL). In July 2000 the perchlorate concentration in the sample from well F-6 was measured at 10 μg/L (significantly above the laboratory PQL) and by January 2001 it had risen to 250 μg/L. Since January 2001, perchlorate concentrations in samples from well F-6 have fluctuated between 56 and 300 μg/L.

Following the initial increase in perchlorate concentrations at well F-6, samples from well F-3 were again tested for perchlorate. Though no perchlorate was detected in the F-3 sample collected in January 2001, by April 2001 perchlorate was detected in well F-3 at 18 μg/L. Perchlorate concentrations then rose to a high of 48 μg/L in July 2001, after which it declined to a low of 17 μg/L just before the well went dry in January 2002.

Perchlorate has not been detected in any other County monitoring wells.

1.2.3 Recent Perchlorate Investigation

Following identification of perchlorate in monitoring well samples, the RWQCB issued Cleanup and Abatement Order No. R8-2003-0013 on January 17, 2003. In response to that Order, the County prepared a Work Plan to investigate perchlorate impacts to soils and groundwater near the former Bunker Area, east of the MVSL (Work Plan dated March 2003). The groundwater components of the Work Plan were completed in October 2003 and a project report was subsequently submitted to the RWQCB (GeoLogic Associates, October 2003). Work completed for this earlier investigation included:

- Literature and aerial photograph review to identify potential sources of perchlorate in the area.
- Excavation of 17 shallow exploratory soils borings within stockpiled bunker debris and associated soils at the Robertson's Ready-Mix aggregate processing plant located east of the former Bunker Area.
- Excavation of 5 deep exploratory soil borings within an accessible portion of the former Bunker Area.
- Installation of 57 temporary wells and 13 permanent groundwater monitoring wells upgradient, cross-gradient, and downgradient of the former Bunker Area.
- Development of a three-dimensional numerical groundwater model of the project area to simulate groundwater flow and contaminant transport conditions near the site and to evaluate alternative responses to groundwater impacts in the area.

Based on the results of the field and laboratory investigation, and as supported by the results of the numerical groundwater model that was prepared for the project, GeoLogic Associates concluded that:

- The MVSL was not a significant source of perchlorate to the local groundwater system
- The detection of only trace concentrations of perchlorate and the absence of explosive constituents in samples collected from bunker debris stockpiled at the Robertson's Ready-Mix plant suggests that these soils do not pose a significant threat to water quality in their current condition.
- While the soil samples that were collected from beneath the former Bunker Area also failed to identify significant concentrations of perchlorate, the historical use of the property and detection of elevated concentrations of perchlorate in groundwater beneath the former Bunker Area suggests that soils in this area could contain elevated concentrations of perchlorate.
- Groundwater downgradient of the former Bunker Area has been impacted by elevated concentrations of perchlorate and a variety of VOCs. Perchlorate concentrations in temporary wells were as high as 820 μg/L at well F-6A, 710 μg/L at well N-5, 350 μg/L at well N-3, and 267 μg/L at well N-8 (Figure 1). Within permanent wells, perchlorate was measured at concentrations as high as 1000 μg/L at well N-3 (currently only 100 μg/L), 530 μg/L at well N-5, and 310 μg/L at well N-8. The most commonly detected VOC was trichloroethene, which was found at concentrations that commonly exceeded its maximum contaminant level (i.e., > 5 μg/L).

- The spatial distribution of perchlorate impacts suggests that the 1999 perchlorate release to groundwater from the former Bunker Area is relatively restricted and does not extend significantly more than about 4000 feet to the southeast (downgradient).

- Perchlorate-related impacts that have been identified in municipal production wells in the region do not appear to be associated with the Bunker Area release.

1.2.4 Additional RWQCB Requirements

Following submittal of the October 2003 project report, the RWQCB presented review comments to the County in a letter dated January 15, 2004. The most significant issues raised by the RWQCB with regard to the soil and groundwater characterization included:

- The RWQCB agreed that no information exists to suggest that the MVSL itself is responsible for perchlorate impacts to groundwater in the area.

- Owing to the relative absence of perchlorate in soil samples obtained from bunker area debris stockpiled at the Robertson's Ready-Mix plant, this phase of the investigation is considered complete.

- Recognizing the detection of low concentrations of perchlorate and VOCs in soil samples collected within the eastern portion of the former Bunker Area, and considering the detection of elevated perchlorate concentrations in select groundwater samples obtained in this area, the County may be required to conduct further soil and groundwater investigations. These studies may occur as part of any "closure" work required by the California Department of Toxic Substance Control (DTSC).

- The RWQCB ordered that a Work Plan be submitted for further characterization of impacted groundwater conditions. The RWQCB Order requires that the Work Plan include provisions for installation of 5 additional groundwater monitoring wells to better delineate the limit of perchlorate impacts.

- Noting the disparity between hydraulic parameters included in a U.S. Geological Survey numerical model of the Rialto-Colton Basin and the values included in GeoLogic Associates' numerical model of the area downgradient of the former Bunker Area, the RWQCB concluded that GeoLogic Associate's model requires further verification to determine the downgradient extent of the contaminant plume.

- In order to develop a groundwater model for the perchlorate and VOC plumes in the immediate vicinity of the former Bunker Area, and possibly to extend the model to include other impacted wells within the Rialto-Colton Basin, the RWQCB also directed the County to submit a second Work Plan for development of a "conceptual groundwater model".

- Since the Cleanup and Abatement Order requires development and submittal of a Remedial Action Plan (RAP), the RWQCB further required the County to immediately begin work on the RAP and prepare a Work Plan that indicates the steps that the County will take to develop and implement it.

2.0 SCOPE OF WORK

2.1 GENERAL

This Work Plan addresses the RWQCB's request for a RAP Work Plan. The RWQCB's request for Work Plans for monitoring well installation and enhanced groundwater modeling have been submitted separately. Individual elements of the RAP project are discussed in the following sections.

2.2 COORDINATION WITH RWQCB AND DTSC

In addition to reviewing data as it becomes available from the new groundwater monitoring wells and from the enhanced groundwater model of the project area, the County will work with the RWQCB and DTSC to review alternative mitigation approaches. It is expected that these discussions will address both interim measures that may be taken to contain and treat impacted soils and groundwater even as investigative work continues, as well as broader solutions that address the fully characterized extent of impacts.

2.3 BUNKER AREA CLOSURE PLAN

A Closure Plan will be prepared that details the measures that the County will take to investigate, delineate, and treat impacted soils within the former Bunker Area. Since this area includes a substantial inert soil stockpile and will ultimately be excavated to significant depth as a part of the future development of MVSL Unit 5, the closure work will be coordinated with ultimate site improvement. It is anticipated that monitoring and removal of a majority of impacted soils will be completed as a part of this development and any residual constituents that might remain below the depth of excavation will be immobilized by construction of a double composite liner. Since the liner system includes a number of barrier layers (i.e., two membrane components and two clay components) and leachate collection systems, once installed the potential for additional impacts to reach groundwater will be essentially eliminated.

Since development of MVSL Unit 5 will necessitate excavation of several million cubic yards of stockpile and native soils, the Closure Plan will identify how and when these stockpiled soils will be removed and how they will be tested for impacts. Since previous land use in the former Bunker area suggest that perchlorate use in the area may have taken place in relatively small areas of the total footprint, the Closure Plan will also identify Areas of Concern (AOC) where soils testing will be more extensive. Once identified, significantly impacted soils will be segregated and treated.

At a minimum, the Closure Plan will be developed to identify the following:

- Substantiated contaminant cleanup standards.
- Procedures, protocols, and schedule for removal of stockpiled soils from the former Bunker Area.
- Areas of Concern (AOC) within the former Bunker Area where soils testing will be more extensive.
- Details of the soil testing program, including:
  - Frequency of testing (both horizontally and vertically) within general areas and in AOC.
  - Soil sampling equipment, procedures, and protocols.
  - List of potential contaminants that will be included in laboratory analyses.
  - Methods for identification and delineation of "hot areas" where soils will need to be removed for treatment.
  - Methods for removal and treatment of impacted soils.
  - Criteria for certifying closure of specific areas within the Bunker Area.
  - Criteria for certifying closure of the entire Bunker

2.4 ENGINEERING EVALUATION OF MITIGATION ALTERNATIVES

2.4.1 General

An Engineering Evaluation of Mitigation Alternatives (EE) will be prepared that identifies and assesses methods that are available to contain and treat impacted groundwater downgradient of the former Bunker Area. The EE will take into account the nature and extent of groundwater impacts, physiographic areas where plume containment might be achieved, standards for groundwater cleanup, advantages and disadvantages of technologies that might be employed to treat groundwater, and costs that might be accrued for the project.

2.4.2 Mitigation Approach

The project approach and objectives will be defined considering the following:

- Depth to groundwater.
- Contaminants of Concern
- Contaminant distribution and concentrations.
- Cleanup / Contaminant areas.
- Cleanup / Containment requirements.
- Treatment system objectives.
- Volume of water to be treated.
- Effluent reuse or discharge options.
- Treatment plant location.
- Treatment system components including emission control equipment.
- Long-term groundwater extraction rates / volumes.
- Operations and maintenance requirements, including labor, utilities, and chemicals consumption.

2.4.3 Preliminary Screening of Mitigation Alternatives

Once the project approach and objectives have been identified, a variety of plume containment and treatment technologies will be considered in a preliminary screening to determine whether these approaches warrant additional evaluation. Specifically, both in situ and ex-situ plume containment measures will be considered, as will both in situ and ex-situ treatment technologies. Post-treatment water disposal alternatives will also be addressed.

2.4.4 Evaluation and Ranking of Viable Technologies

Once viable mitigation technologies are identified, their operating requirements and mitigation efficacy will be considered in greater detail. A conceptual design of each system will be described to identify design considerations and associated costs. The relative advantages and disadvantages of the different systems will then be assessed and a ranking will be prepared to assist in selection of the most appropriate response to impacted groundwater conditions in the area. Ranking criteria are expected to include:

- Perchlorate and VOC Removal Effectiveness
- Post-Treatment Potability
- Constructability
- Operations and Maintenance (O&M) Efficiency
- Capital Costs
- O&M Cost

2.5 ENGINEERING EVALUATION (EE) REPORT

Using the information developed during completion of the work described above, an EE document will be prepared that identifies the nature and extent of the release, assesses alternative remediation measures, and presents the County's planned mitigation response. The EE report will be submitted first as an Interim document that reflects the current understanding of the nature and extent of groundwater impacts associated with the former Bunker Area, and which identifies an optimal response to these conditions. Following completion of the forthcoming well installation and groundwater modeling work, the EE report will be updated to incorporate the supplemental data and, if necessary, to re-evaluate the responses that might be undertaken to address the refined plume characteristics.

2.6 REMEDIAL ACTION PLAN

Following RWQCB and DTSC review and approval of the Bunker Area Closure Plan, and after RWQCB review and approval of the final Engineering Evaluation of groundwater mitigation alternatives, the County will prepare and submit a Remedial Action Plan report that addresses the following:

- Description of the nature and extent of the release.

- Proposed soil and groundwater cleanup standards together with data necessary to justify such limits.
- Description of the remedial response measures that the County will undertake to remove and treat impacted soils within the former Bunker Area (i.e., "close" the Bunker Area).
- Description of the groundwater corrective action measures that will be implemented to mitigate identified groundwater impacts.
- Monitoring measures that will be taken to verify the adequacy of the proposed mitigation responses.

3.0 PROJECT SCHEDULE

The anticipated schedule for completing the work described above is presented below. Although every effort will be made to keep the project schedule "on track", it is possible that data availability (e.g., well construction delays) could delay the work.

The following milestones in the proposed schedule are critical to the prompt completion of the project work:

- Submittal of Interim EE of Mitigation Alternatives - Feb. 29, 2004
- Meet RWQCB and DTSC to Review Project Goals – March 26, 2004
- Response to RWQCB Comments to Interim EE – 2 weeks after receipt
- Submittal of Bunker Area Closure Plan - July 16, 2004
- Response to Agency Comments on Closure Plan – 2 weeks after receipt
- Submittal of Updated EE of Mitigation Alternatives – January 30, 2005
- Response to Agency Comments of Updated EE – 2 weeks after receipt
- Submittal of Remedial Action Plan – 60 days after approval of Plume characterization, EE and Closure Plan.

4.0 CLOSURE

This Work Plan is based on the data described above and referenced herein. GeoLogic Associates should be notified of any conditions that differ from those described herein since this may require a re-evaluation of the work-plan elements presented herein. This Work Plan has not been prepared for use by other parties and projects other than those named or described above. It may not contain sufficient information for other parties or other purposes.

GeoLogic Associates

Gary L. Lass, C.E.G., C.H.G
President

5.0 REFERENCES

GeoLogic Associates, February 2004a, "Work Plan, Installation of Groundwater Monitoring Wells in Response to RWQCB Investigative Order #r8-2003-013 for Investigation of Perchlorate and Volatile Organic Compounds in Groundwater", prepared for the San Bernardino County Solid Waste Management Division.

GeoLogic Associates, February 2004b, "Work Plan, Supplemental Groundwater Modeling for Investigation of Perchlorate and Volatile Organic Compound Impacts to Groundwater, San Bernardino County, California, In Response to Regional Water Quality Control Board Order No. R8-2003-0013", prepared for the San Bernardino County Solid Waste Management Division.